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THE ANT LARVAE OF THE SUBFAMILY FORMICINAE[1]

PART II

GEORGE C. WHEELER AND JEANETTE WHEELER
Department of Biology, University of North Dakota

Tribe **Oecophyllini** Emery

Genus **Oecophylla** F. Smith

Sausage-shaped; slightly curved ventrally; terete; diameter nearly uniform, greatest at the fourth abdominal somite, diminishing slightly toward either end. Head on the anterior end; no neck. Anus postero-ventral. Segmentation indistinct. Integumentary spinules coarse and isolated or in short rows. Body hairs very few, minute, simple, acute. Cranium subtrapezoidal in anterior view, slightly narrowed ventrally, dorsal corners broadly rounded. Antennae minute. Head hairs few, very short, simple, acute. Labrum small, bilobed, with only two hairs on the anterior surface. Mandibles very small and feebly sclerotized; basal three-fifths broad and subtrapezoidal in anterior view; apical two-fifths forming a long straight slender sharp-pointed conical tooth; ridges few. Maxillae broad and apparently adnate; integument granular; palp a very small skewed peg; galea a very small knob. Labium a small frustrum; palp a very small irregular projection; opening of sericteries narrow and salient.

This genus "comprises the famous and vicious 'tree-ants,' or 'tailor ants,' which make peculiar globular or elliptical nests of leaves on living trees. The leaves are spun together with films of white silk, which is supplied by the larvae" (Wheeler, 1922*a*, p. 225; see also p. 211). When a nest is to be constructed or repaired, workers pull leaves together and hold them in place, while other workers bring out larvae to be used as shuttles. Each larva is grasped tightly at its middle by the mandibles of the worker; its head is directed forward. Here attention should be called to the shape of the larva—nearly straight, with the head on the anterior end. This makes it possible

[1]The research on which this article is based was aided by a grant-in-aid from the Sigma Xi Research Fund.

for the worker to attain some degree of accuracy in attaching the silk—a greater degree at least than would be possible with a larva of the typical formicine shape, which has a flexible neck which is strongly curved ventrally. The worker touches the labium of the larva to one leaf, pausing long enough for the deposition of a little silk on its surface; then the larva is moved across the narrow gap to the neighboring leaf, spinning out a fine silken thread as it goes; there is another pause for attaching this thread to the second leaf; then back to the first leaf; and so on, until a delicate film or tissue "somewhat resembling cigarette paper" (Green, 1896, p. ix) is fabricated.

We have cited below, under the discussions of species, the references from the literature on the use of larvae in nest construction. As Emery (1925, p. 51) so aptly expressed it, "aujourd'hui, les publications sur la nidification d'*Oecophylla* et des Fourmis qui suivent la même méthode . . . constituent une littérature assez considérable." Whether *assez* is translated to *rather*, or to *enough*, this is still an understatement.

On the same page Emery also said: "Les larves d'*Oecophylla* ne filent pas de cocon, quoiqu'elles aient des glandes séricigènes très développées." See also above under the subfamily.

Wheeler, 1915:—"It would seem that the habit of employing the larvae for spinning the nest tends to make them develop into adults of uniform stature and shape. It is not easy to understand why this should follow" (p. 332). "Apparently . . . in this genus the spinning habit has been shifted back *en bloc* to an early larval stage and is no longer manifested for cocooning in late larval life" (p. 333).

Oecophylla smaragdina (Fabricius)

Plate V, figs. 17–20

Sausage-shaped; slightly curved ventrally; terete; diameter nearly uniform, greatest at the fourth abdominal somite, diminishing slightly toward either end. Head on the anterior end; no neck; posterior end round. Anus posteroventral. Leg vestiges present. Somites indistinct. Integument spinulose, the spinules coarse and isolated or in short rows. Body hairs very few, most numerous on the prothorax; minute (0.006–0.036 mm long), simple, slightly curved, acute; with alveolus and articular membrane. Cranium subtrapezoidal in anterior view, slightly narrowed ventrally, dorsal corners broadly rounded, about a third broader than long; gula with transverse spinulose ridges. Head hairs few, very short (0.036–0.045 mm), straight to slightly curved, simple, acute; alveolus and articular membrane present. Antennae minute, each with three sensilla. Labrum small; bilobed due to a wide impression of the ventral border; breadth (at base) twice the length; narrowed ventrally; anterior surface with two hairs and about six sensilla; ventral border with a few spinules; posterior surface spinulose, the spinules minute and in rows which radiate from the dorsolateral angles, the rows continuous near the base but broken distally; about 12 sensilla near the middle of the posterior surface. Mandibles very small; feebly sclerotized; wedge-shaped, with the edge medial; basal three-fifths very broad and subtrapezoidal in anterior view; apical two-fifths forming a long straight slender smooth sharp-pointed conical tooth; anterior and posterior surfaces with a few longi-

tudinal ridges. Maxillae broad and apparently adnate; surface conspicuously granular; palp a very small skewed peg bearing five sensilla; galea a very small knob bearing two sensilla. Labium a small frustrum; anterior surface conspicuously granular; palp a very small irregular projection bearing four sensilla; opening of sericteries narrow and salient. Hypopharynx densely spinulose, the spinules arranged in subtransverse rows, the rows grouped in two subtriangles which have their bases near the middle. (Material studied: seven larvae from Assam, courtesy of Dr. A. C. Cole.)

Ridley (1890, p. 346) published the earliest account of the use of the larvae of this species in weaving. It had been assumed previously that the silk of the nest was secreted by the workers. Brief accounts of this function of the larvae were given by Ridley (1894, p. xxxii), Green (1896, p. ix and 1900), and Jacobson and Wasmann (1905, p. 133, referring to Ridley, 1890, and to Green, 1896).

Doflein's (1905) account is classic. It was translated by Wheeler (1910, pp. 218–220). Doflein's Fig. 3, showing a brigade of workers drawing the edges of leaves together while other workers manipulate the larvae, is reproduced by Wheeler (1910) as Fig. 122 on page 217; Fig. 4, showing a worker holding a larva in its mandibles, as Fig. 123 on page 219.

Bugnion (1909; 1923, p. 17–18 = 1924, p. 440–441) published brief accounts of weaving accompanied by a figure of a worker carrying a spinning larva (1909, Fig. 3 = 1923, Fig. 2 = 1924, Fig. 12; repeated by Forel, 1923, Fig. 14, p. 96 (= 1928, Vol. II, Fig. 130 on p. 278). He insisted that only young larvae (up to two or three millimeters in length) are used in weaving (1924, p. 446). "Les larves, en quantité énorme, aveugles et apodes, présentent les dimensions les plus diverses à partir des nouveau-nés groupés à proximité des paquets d'oeufs, jusqu'aux gros vers dodus de couleur blanche, longs de 11 à 12 mm., destinés à former des nymphes femelles" (1923, p. 25 = 1924, p. 424).

Subsequent brief accounts were published by Bischoff, 1927, p. 303; Brun, 1924, pp. 53–57; Forel, 1923, pp. 96–99 (= 1928, Vol. II, pp. 278–281); Goetsch, 1937, p. 50; Jacobson and Wasmann, 1905, pp. 133–134; Jacobson, 1907, p. 36; Lefroy and Howlett, 1909, p. 231; Lefroy, 1923, p. 527; Mann, 1934, p. 187; Schwarz, 1946, p. 114; and probably many others.

Doflein's two figures have been copied by Berlese (1925), Brun (1924), Escherich (1906 and 1917), Forel (1923), Wheeler (1910) and probably by others. Doflein's Fig. 3 has been copied by Forel (1928), Goetsch (1937), Metcalf and Flint (1932), Roughley (1947) and Schwarz (1946). Sharp published a figure (1909, Fig. 60 on p. 147) of a worker using a larva for spinning. Mann's paper (1934) includes a colored reproduction (Pl. IV) by Hashime Murayama depicting workers and larvae engaged in nest construction.

Forel and Jacobson, 1909, p. 238: The larvae are passive while weaving; the workers themselves apply the larval mouthparts to the point to which the thread is to be attached.

It has been suggested that the larvae are unable to spin cocoons, because their supply of raw material is used up in nest construction (Green, 1904, pp. 73–74; Bugnion, 1909, p. 512, 1923, p. 26 and 1924, p. 449), but Wheeler (1915, p. 326) questioned this interpretation.

Lefroy and Howlett have figured (1909, Fig. 135 on p. 233) a "queen watching over larvae when commencing to found a new nest." (Referred to by Wheeler, 1915, p. 330.) "A colony will have many small depots on one tree, each consisting of a number of leaves webbed together and containing a colony of Coccids or a store of dead dry insects. If one is opened and patiently watched, it will be seen that the workers draw the leaves together by their mandibles and legs, while others, from inside, web them together with silk produced from a larva held in the jaws" (pp. 230–231).

"They also use these grubs to spin webs when fortifying the tree in which they live against the small ants with which they are continually at war. Leaf stipules, dirt, small stones, etc., are brought by the 'red ants' and inserted in the web spun with the aid of the small grubs. On the tree I am watching now there is nearly a complete circle around the trunk (a foot or more in diameter)" (Green, 1896, p. ix). This was translated freely (but incorrectly) and with some embellishment by Chun (1903, p. 129) and by Jacobson and Wasmann (1905, p. 134).

Doflein's figure of a larva of this species (1906, p. 487) shows the highly developed salivary glands. It has been copied by Forel (1923, Fig. 11B = 1928, Vol. II, Fig. 133), Karawaiew (1906, Fig. 13) and Wheeler (1910, Fig. 124D). Karawaiew (1929, p. 255) discusses the histology of the salivary glands, which produce the silk.

Long (1901) reports the use of this species, both adults and brood, as human food in the province of Bastar (India). Larvae and pupae are used as fish bait in eastern Bengal (Dutt, 1912, p. 259).

Oecophylla smaragdina subnitida Emery

"In the nest of the tailor ant was an amazing little moth (*Liphyra brassolis*). . . . The little caterpillar. . . feeds on the larvae of the ants" (Mann, 1948, p. 307).

Oecophylla smaragdina virescens (Fabricius)

The earliest account of the use of larvae of this ant in nest weaving is apparently that of Saville-Kent (1897, pp. 253–254); it is illustrated by three crude figures on Plate IX—(1) ants holding leaves together while one worker carries a larva, (2) a worker carrying a larva and (3) a larva. Dodd reported (1902*a*, p. 138) his original observations, which were quoted by Wheeler (1910, pp. 220–221). Wheeler also recorded original observations (1915, pp. 328–329); he described the larvae as "milk-white" and stated that "only very young larvae, about 2–3 mm. in length, were employed" in weaving. Brief accounts of weaving have been given by Dodd (1928, p. 128), O'Brien (1910, p. 670) and Roughley (1947, p. 177).

This ant also uses the larval silk in the construction of shelters for Homoptera and caterpillars (Dodd, 1902*a*, p. 138; Roughley, 1947, p. 179).

The colony-founding queen also employs her first larvae in the construction of her first woven nest (Dodd, 1928, p. 125; Wheeler, 1915, p. 330).

Dodd (1902*b*, pp. 154–155) suspected the caterpillars of *Liphyra brassolis* Westwood of feeding on the larvae of this ant. (Mentioned by Wheeler, 1910, p. 359).

Roughley (1947, p. 179) reported that the larvae of *virescens* were used as human food by the aborigines of northern Queensland; they were "eaten raw, sometimes after rolling them into a ball between the palms of the hands."

Oecophylla longinoda (Latreille)

Apparently similar to *smaragdina*. (Material studied: 11 damaged integuments from the Congo.)

Chun (1903, p. 129) noted that the spinning glands were enormously developed. (Referred to by Jacobson and Wasmann, 1905, p. 135, by Karawaiew, 1906, p. 371 and by Wheeler, 1910, p. 218).

Eidmann, 1944, p. 461: "Die Seide entstammt den Spinndrüsen der Larven, die von den Ameisen wie Weberschiffchen benutzt werden, ein interessanter Fall der Verwendung eines 'Werkzeuges' im Tierreich."

Kohl (1906, pp. 167–168) observed the use of larvae in weaving.

Tribe **Camponotini** Forel

Thorax and first abdominal somite forming a short stout neck, which is sharply marked off from the rest of the abdomen and which is strongly curved ventrally, so strongly in fact that the mouth parts may be directed posterodorsally and can even be applied to the ventral surface of the anterior abdominal somites. Rest of abdomen elongate-subellipsoidal and straight; diameter greatest at the fourth and fifth abdominal somites, decreasing but slightly toward either end. The posterior half of the ventral surface of the second abdominal somite is raised to form a transverse welt and, on either side, ridges from this welt extend forward to form the sides of a trough, the praesaepium. Anus subterminal. Segmentation distinct. Floor of praesaepium spinulose. Body densely and uniformly covered with short hairs, except on the ventral surface of the thorax and abdominal somites I and II where they become sparse. Five types of hair-shapes occur in the tribe: (1) branched (typically with 2 to 6 branches, but there may be as many as 12); (2) simple, short and slightly curved; (3) simple, long and whip-like; (4) denticulate; (5) uncinate. One type, the branched in most species, is numerically predominant; other types are sparsely represented. Branched and simple hairs are generally the shortest, whip-like and uncinate hairs the longest; denticulate hairs are usually intermediate. Branched hairs have all branches in the same plane and they are so attached to the integument that this plane is transverse. Typically a species has three of these five types, but the number ranges from one to four; thus no species has all types. Head hairs numerous; a conspicuous naked area in the form of an inverted V. Four types of head hairs occur in the tribe: (1) branched (typically bifid or trifid, but there are also four-branched), (2) simple, (3) whip-like, (4) denticulate. A species usually has two of these types but may have one, three or four. Labrum subparabolic in anterior view; somewhat broader (at base) than long; chiloscleres present; posterior surface with numerous (16–30) sensilla. Mandibles rather small; basal third broad and rather thick; distal two-thirds thin and blade-like; apical tooth abruptly marked off, short and slightly

curved anteriorly; lateral outline saddle-shaped; middle half of mesal border denticulate. Maxillae swollen ventrolaterally; apex in the form of a slender cone which is directed medially; mesal surface with rows of minute spinules. Anterior surface of labium spinulose.

This tribe presents two distinctive features which are worthy of special consideration:

Chiloscleres.—We have coined this term from the Greek *cheilos*, lip, and *skleros*, hard, to designate the pair of conspicuous dark brown spots, one at either side of the labrum. Each chilosclere consists of a bar along the lateral margin of the labrum; from this a branch bar extends (almost at a right angle) out to the anterior surface, where it fades out; these bars are apparently formed from enormously thickened and hardened portions of the cuticula. See text fig. 2.

The chiloscleres were figured for *Polyrhachis muelleri* by Karawaiew (1906); for *Camponotus aethiops* ("var. *concava*" and "var. *andria*") by Menozzi (1936); for *C.* (*Colobopsis*) *schmitzi* by Stärcke (1933). Menozzi referred to them as strongly chitinized thickenings ("ispessimento fortemente chitinizzato"), Stärcke as "bord chitineux du labrum".

We have no clue as to the function of the chiloscleres but are inclined to the opinion that they are parts of the trophorhinium; by rubbing the roughened anterior surface of the mandibles, which they probably do when the latter are moved from side to side, they would aid in the trituration of food. Chiloscleres are not present in young larvae.

Praesaepium.—We have taken this Latin word meaning trough or manger to designate the shallow depression on the ventral surface of certain anterior abdominal somites. The most common form is probably typified by the praesaepium of *Camponotus* (*Myrmaphaenus*) *novogranadensis*. Here the posterior half of somite II is raised to form a transverse welt; on either side ridges from this welt extend forward to form the sides of the trough. The structure attains its most elaborate form in the subgenus *Colobopsis* where the anterior border of somite II is produced anteriorly to form a thick transverse welt which overhangs the depressed ventral surface of somite I. This is reminiscent of the trophothylax of pseudomyrmine larvae (Wheeler and Bailey, 1920) and probably serves the same function in a rudimentary way. In the subgenus *Camponotus* the praesaepium is probably temporary; there are no welts but the ventral surface of somite II is capable of being depressed to form a crude sort of trough.

The praesaepium is apparently lacking in young larvae and in mature larvae ready to pupate.

The floor of the praesaepium is always conspicuously spinulose.

Some observations (from the notebook of the senior author, 1920) on a living larva of *Camponotus americanus* in an artificial nest, are pertinent here: "The mature larva (length 4.5 mm) lay on its back with its neck strongly curved ventrally and its head resting in the shallow trough. The trough was filled with a clear fluid in which the mouth parts were immersed. There was also in this liquid immediately under the mouth a small brownish-yellow pellet. When examined under the microscope this pellet was found to consist of a tangled mass of hairs, a few of them branched, but most of them long and uncinate

like those of the young larvae. The mandibles were moving rhythmically from side to side, but they did not meet. In all probability the larva had just finished making a meal of some of its younger siblings."

The genera of this tribe are so similar that we cannot distinguish them; hence we have not attempted to key them. *Colobopsis* is, however exceptional: differences of generic magnitude separate it not only from the other subgenera of *Camponotus* but also from other genera of Camponotini.

Genus **Camponotus** Mayr

Head small. Cranium subrectangular in anterior view, with all corners rounded. Antennae small. Gula spinulose. Head hairs long. Mandibles with only a few longitudinal ridges; a few of those on the anterior surface bear minute spinules; most of those on the posterior surface bear a comb of long spinules. Labial palps a pair of low knobs.

Adlerz, 1886:—"The larvae are more flattened than those of most other ants and are also very flexible and active. The hairy covering, especially on the smaller larvae, is composed of closely set branched hairs with finely attenuated ends, and scattered among these on the dorsal surface are long bent hairs in which the ends are barb-like and bent back; and which hook on to one another" (p. 293, translated from the Swedish by Professor Edith E. Larson). Hairs with long thin, fine-pointed branches are characteristic of this genus (p. 51). "The body is flattened and its anterior third is strongly bent ventrally. . . . The bent head is often seen touching the ventral side of the body, the same condition as in the embryonic stage. These larvae are very active" (p. 52). The larval period in an incipient colony lasted about 30 days (p. 53). Internal anatomy, pp. 58–64.

Clausen (1940, p. 221):—The eucharid genus *Stilbula* appears to be most frequently associated with *Camponotus*. As far as known, eucharid larvae are parasitic upon the mature larvae and pupae of ants.

Dodd, (1906, p. 123) has recorded *Schizaspidia doddi* Bingham with *Camponotus* sp. from Queensland. Presumably the eucharid larvae were parasitic on the ant larvae.

Emery, 1899, p. 5:—The mandibles of ponerine larvae are much larger than those of the larvae of *Camponotus*.

Emery, 1925, p. 6:—See above under the subfamily.

Forel, 1874, p. 388 = 1920, p. 265–6:—"Chez les *Camponotus* [les larves] ont la peau flasque, et sont comprimées dans le sens qui va du dos au ventre; leur partie buccale est brusquement recourbée, tandis que le reste du corps est droit. Les larves sont très mobiles."

Furniss, 1944, Fig. 1 J on p. 4:—Photograph of a larva of *Camponotus* sp. in side view.

Gantes, 1949: "Plus évoluées: les larves sont moins agiles. Je ne les pas vues manger seules. Les mandibules sont plus massives. Les poils plus clairsemés. . . . On trouve des poils en crosse chez les jeunes larves" (p. 88). "Ces poils chez la larve néonate sont répartis sur le dos et tout autour du bout de l'abdomen, puis aux stades suivants on ne les a plus que dorsalement et sur les derniers segments abdominaux. Chez la larve adulte il n'y en a plus" (p. 87).

Goetsch, 1930:—"Die Fütterung zum mindesten für die Grösse der Larven eine Rolle spielen Kann" (p. 384). A diet of animal food (or a mixed diet) produces larger larvae than a vegetarian diet. This is shown by profiles of queen larvae, (Fig. 10–12, p. 385).

Muir (1911, p. 61) referred to large jet black ants which tunneled in dead tree trunks. "Bears . . . roughly devour the eggs, larvae, parent ants and the rotten or sound wood of the cells, all in one spicy acid hash. The Digger Indians also are fond of the larvae and even of the perfect ants, so I have been told by old mountaineers."

Parker and Thompson (1925, p. 393) have reported *Stilbula cynipiformis* Rossi with *Camponotus* sp.; presumably the eucharid larva had been parasitic on the ant larva.

Wheeler, 1933*a*, p. 10:—Colony-founding queens of *Camponotus* may devour some of their own larvae.

Subgenus **Camponotus** Mayr

Praesaepium less elaborate and probably not permanent.

Camponotus noveboracensis (Fitch)

(Plate V, figs. 1–13)

Thorax and first abdominal somite forming a short stout neck, which is sharply marked off from the rest of the abdomen and which is strongly curved ventrally, so strongly, in fact, that the mouth parts may be directed posterodorsally and can even be applied to the ventral surface of the anterior abdominal somites. Rest of abdomen elongate-subellipsoidal; diameter greatest at the fourth and fifth abdominal somites, decreasing but slightly toward either end. The prothorax bears a pair of lateral swellings and (adjacent to the head) a ventral swelling. Ventral surface of second abdominal somite capable of being depressed to form a trough (the praesaepium) in which the head of the larva often rests. Posterior end round-pointed. Anus subterminal. Leg vestiges present. Thirteen differentiated somites. Body densely

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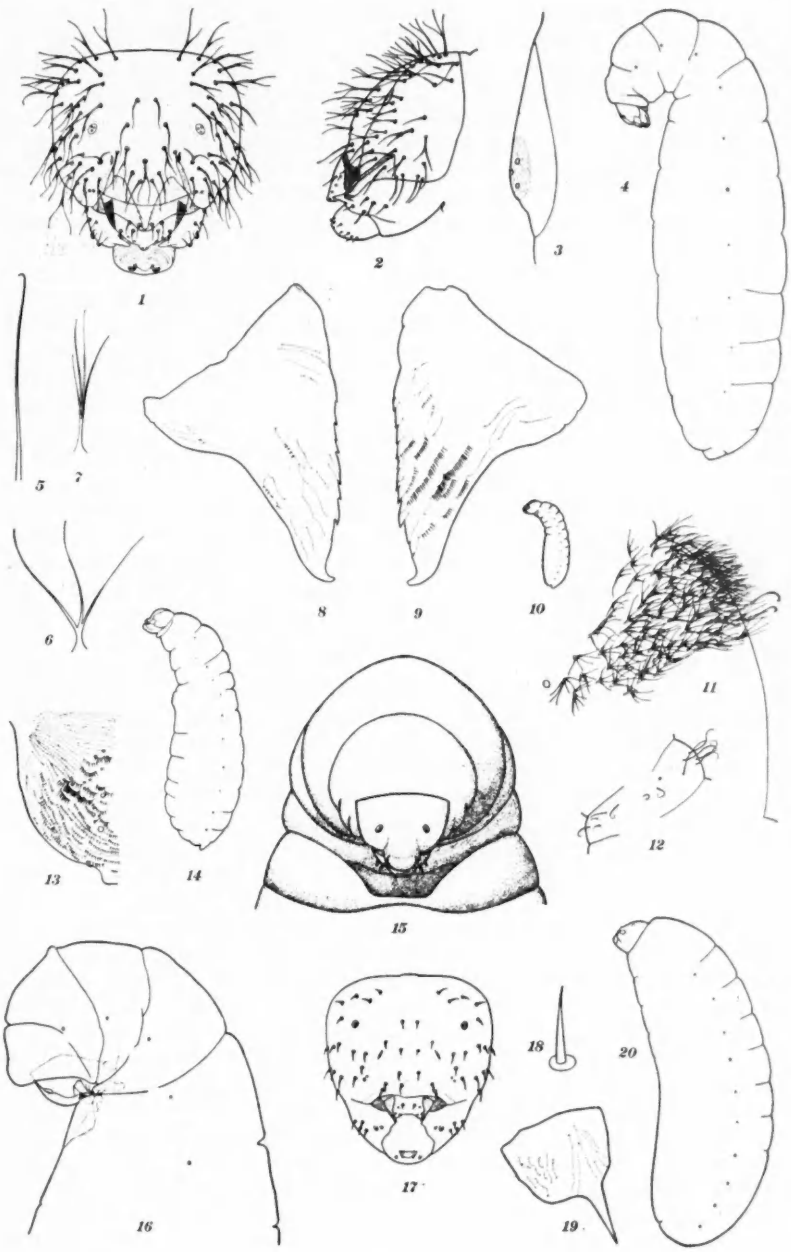
EXPLANATION OF PLATE V

Camponotus noveboracensis (Fitch). FIG. 1, head in anterior view, ×44. FIG. 2. Head in side view, ×44. FIG. 3. Left antenna in side view, ×185. FIG. 4. Larva in side view (hairs omitted), × 8. FIG. 5. Uncinate body hair, ×121. FIG. 6. Branched body hair, ×121. FIG. 7. Branched hair in edge view, ×121. FIG. 8. Right mandible in anterior view, ×185. FIG. 9. Right mandible in posterior view, ×185. FIG. 10. Very young larva (1.5 mm) in side view (hairs omitted), × 8. FIG. 11. Dorsal surface of abdominal somite I in side view showing spiracle and adjacent hairs (other hairs omitted), ×44. FIG. 12. Abdominal somite I of very young larva in side view, showing spiracle and hairs, ×44. FIG. 13. Left half of labrum in posterior view, ×118.

Camponotus (*Myrmaphaenus*) *novogranadensis* Mayr. FIG. 14. An extended larva in side view (hairs omitted), showing the praesaepium, ×10.

Camponotus (*Myrmentoma*) *nearcticus* Emery. FIG. 15. Head and anterior end (hairs omitted), showing praesaepium, ×22. FIG. 16. Head and anterior end (hairs omitted), in phantom view showing mouth parts in praesaepium, ×22.

Oecophylla smaragdina (Fabricius). FIG. 17. Head in anterior view, ×44. FIG. 18. Body hair, ×370. FIG. 19. Right mandible in anterior view, ×185. FIG. 20. Larva in side view (hairs too small to show at this magnification), ×10.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and uniformly covered with short hairs, except on the ventral surface of the thorax and abdominal somites I and II where they become sparse. Hairs of two types: (1) length 0.07–0.18 mm, 2 to 6-branched, all branches in the same plane, generally distributed over the body; (2) length 0.18–0.26 mm, one-hooked uncinate hairs, a few near the middle of the dorsal and lateral surfaces of each abdominal somite. Body hairs apparently without alveolus and articular membrane. Integument of abdominal somites VIII-X and of the ventral surface of the thorax and abdominal somites I and II spinulose, the spinules minute and in short transverse rows. Head small; cranium subrectangular in anterior view, with all corners rounded; slightly broader than long; gula spinulose, the spinules minute and in short transverse rows. Head hairs numerous; long (0.12–0.21 mm); 2 to 3-branched, with the branches long; alveolus and articular membrane present; naked area conspicuous, in the form on an inverted V. Antennae small, each mounted on a low convexity and bearing three sensilla. Labrum subparabolic in anterior view with a small median lobe protruding ventrally; breadth (at base) 1.3X length; anterior surface with 12 hairs and (on or near the ventral border) ten sensilla; posterior surface spinulose, the spinules minute and arranged in rows which radiate from the dorsolateral angles, the rows continuous near the base but broken distally; posterior surface with about 30 sensilla; chiloscleres present. Mandibles rather small; moderately sclerotized; subtriangular in anterior view; basal third broad and rather thick; distal two-thirds thin, blade-like and slightly curved anteriorly; apical tooth short, smooth, round-pointed and curved medially; lateral outline saddle-shaped; middle half of mesal border denticulate; anterior surface with a few short longitudinal ridges on some of which are mounted minute spinules; posterior surface of blade with a few longitudinal ridges, on most of which are mounted combs of rather long spinules. Maxillae swollen ventrolaterally; apex in the form of a slender cone which is directed medially; mesal surface roughened with short rows of minute spinules; palp a small peg bearing four apical and one lateral sensilla; galea a cone bearing two apical sensilla. Labium with the anterior surface spinulose, the spinules short and in transverse rows; palp a low knob bearing five sensilla; opening of sericteries wide and salient, with two projections. Hypopharynx densely spinulose, the spinules arranged in subtransverse rows, the rows grouped in two subtriangles which have their bases near the middle. (Material studied: numerous larvae from New Hampshire, New York and North Dakota.)

Wheeler (1907, p. 16) recorded *Pseudochalcura gibbosa* Provancher from the cocoons of this ant in Michigan. The eucharid larvae were presumably parasitic on the ant larvae.

First-instar larva:—Length 1.4–1.6 mm. Thorax stout and bent ventrally; abdomen somewhat stouter, straight, tapering slightly toward either end. Anus subterminal, with large prominent lips. The prothorax bears a pair of lateral swelling and (adjacent to the head) a ventral swelling. Praesaepium lacking. Thirteen differentiated somites. Body hairs sparse and moderately long, of two types: (1) one-hooked uncinate hairs, with the tips curled, about 0.13 mm long, a few on each somite, the more conspicuous type; (2) simple flexuous

hairs, 0.05–0.11 mm long apparently restricted to ventral surface. Integument of the dorsal surface sparsely spinulose, the spinules minute and in short transverse rows. Head relatively large. Head hairs moderately numerous, short to moderately long (0.009–0.11 mm), of two types: (1) simple and (2) one-hooked uncinate hairs (with the tips more curled than those of body hairs). Each antenna represented by three raised sensilla. Labrum without chiloscleres. Mandibles with the apical tooth vestigial. Maxillae with the apex a frustum; palp a cluster of five raised sensilla; galea a frustum with two sensilla. Labial palp a low conoid with five sensilla; opening of sericteries not evident. Other characters similar to those in the mature larva. (Larvae still in the egg shell, but ready to hatch, are similar to the larvae described above; length of egg 1.2 mm.)

Second-instar larva:—Length 1.7–1.8 mm. Body shape as in first-instar larva but with the abdomen somewhat more voluminous. Body densely and uniformly covered with rather long hairs, except on the ventral surface of the thorax and abdominal somites I and II where they are sparse. Hairs of three types: (1) one-hooked uncinate hairs with the tips curled, 0.14–0.27 mm long, a few on each somite; (2) flexuous hairs, 0.018–0.11 mm long, generally distributed; (3) 2 to 3-branched hairs, 0.07–0.11 mm, generally distributed but lacking on the ventral surface of the thorax. Integument of the dorsal surface of the abdomen spinulose, the spinules minute and in short transverse rows. Head relatively large; gula spinulose. Head hairs numerous; simple and flexuous, rarely 2-branched, 0.07–0.14 mm long. Each antenna represented by three raised sensilla. Labrum without chiloscleres. Apical tooth of mandible vestigial. Opening of sericteries represented by a pair of slight swellings. Otherwise similar to the mature larva.

Camponotus americanus Mayr

Text fig. 1

See above under tribe Camponotini.

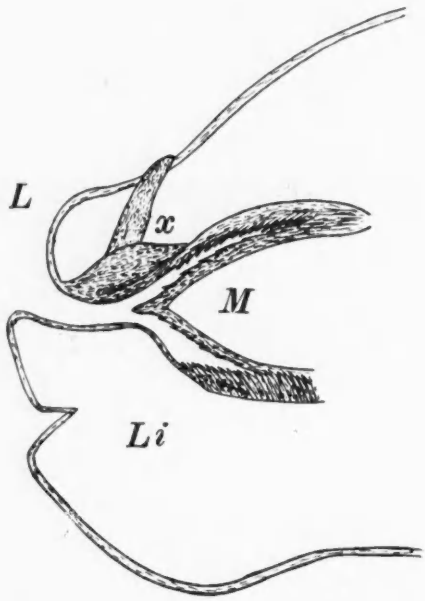
Wheeler, 1910, Fig. 45 on p. 79: Photograph (indistinct) of younger and older larvae.

Camponotus herculeanus (Linnaeus)

Similar to *noveboracensis* except as follows: body hairs more abun dant; uncinate hairs shorter (about 0.14 mm); anterior surface of labrum with about nine hairs and (on or near the ventral border) about 12 sensilla. (Material studied: several larvae from Michigan.)

Eidmann, 1928*a*:—"Die Ameisenlarven sind bekanntlich fusslos und wenn überhaupt, dann nur in beschränktem Masse der Ortsbewegung fähig. Sie können sich nicht an den rauhen Wänden anklammern, wie ihre Pflegeschwestern und müssten daher in den engen hohen Kammern am Grunde hoch übereinandergestapelt liegen, was für ihre Ernährung und Wartung sicherlich höchst unzweckmässig wäre. . . Hafthaare. . . finden sich auf der Rückseite der Abdominalsegmente. Die Thorakalsegmente sind völlig frei davon, ebenso die Ventralseite des Abdomens, abgesehen von den letzten Segmenten, auf deren Ventralseite die Region der Hafthaare um die hintere Rundung des

Abdomens herum eine Strecke weit übergreift. Die Hafthaare zeichnen sich durch ihre Länge und Dicke vor den übrigen Haarkleid der Larven aus, das als gleichmässig dichter Pelz von kurzen Haaren den gesamten Larvenkörper überzieht. Die Spitze der Hafthaare ist zu einem krallenartigen, spitzen Gebilde umgebogen, mit dem ein festes Verankern in einer rauhen Unterlage wohl möglich erscheint. . . . Die Hafthaare sind ziemlich spärlich in dem Haarkleid verteilt und lassen keinerlei Regelmässigkeit in ihrer Anordnung erkennen. Ihre Länge beträgt das Doppelte bis Dreifache der kurzen Haare, die Krümmung zeigt nach den verschiedensten Richtungen. In dem kurzen Pelzkleid der Larven finden sich neben einfachen Haaren in grosser Zahl eigentümliche



TEXT FIG. 1. *Camponotus americanus* Mayr. Longitudinal section through head, × 358; *L*, labrum; *x*, chilosclere; *M*, mandible; *Li*, labium.

baumförmig verästelte Haare von der gleichen Länge wie jene. Es ist sehr leicht möglich, dass die Larven mit Hilfe der Hafthaare an den Wandungen der Kammern aufgehängt werden, gesehen habe ich es nicht, und es wird auch nicht sehr leicht festzustellen sein. Man wird zu diesem Zweck Beobachtungen in künstlichen Nestern anstellen müssen, die entsprechend gebaut sind. Ich habe zwar *C. ligniperda* jahrelang im Versuchsnest gehalten, doch waren diese nicht geeignet (es waren horizontale Gipsnester) um gerade über diesen Punkt Aufschluss zu erhalten. Ich glaube nicht, dass es gelingen wird, ein natürliches Nest in einem lebenden Stamm so schnell zu öffenen, um die Larven noch in ihrer natürlichen Lage beobachten zu können. Die Wirkung der Hafthaare lässt sich, selbst an konserviertem Larvenmaterial noch

sehr schön erkennen. Kleine Watteflöckchen oder ähnliche Fremdkörper haften sehr fest an dem Larvenkörper und die Larven selbst hängen fest aneinander. Letztere Eigentümlichkeit, das Zusammenklumpen der Larven vermöge der Hafthaare ist biologisch von Bedeutung, besonders für den Transport kleiner Larven und die rasche Räumung des Nestes bei Gefahr. Wir finden daher auch Hafthaare bei den larven erdbewohnender Ameisen (*Pheidole*, *Solenopsis*, u. a.) Das Vorkommen der Hafthaare bei den Larven der Rossameise Kann daher zwar kein sicherer Beweis dafür sein, dass dieselben zum Aufhängen an den steilen Kammerwänden dienen; doch erscheint dies unter den obwaltenden Verhältnissen sehr wahrscheinlich." (pp. 237–240). Fig. 7 on p. 239: larval hairs.

Eidmann, 1943, pp. 250–254:—Young larvae (*kleine Eilarven*) overwinter in the nest.

Goetsch, 1937, p. 137: life cycle—egg 16–27 days, larva 8–15 days, pupa 14–92 days.

Stärcke, 1933, pp. 30–31: See under *C.* (*Colobopsis*) *schmitzi*.

Stärcke (1939, p. XIX):—The antennae have the cuticle very convex.

Camponotus herculeanus obscuripes Mayr

Clausen (1941, p. 57) recorded this ant as the host of *Stilbula tenuicornis* (Ashmead) in Korea; presumably the eucharid larvae were parasitic on the ant larvae.

Camponotus japonicus Mayr

Clausen (1923) reported the eucharid *Schizaspidia tenuicornis* Ashmead as ectoparasitic on the larvae and pupae of this ant in Japan. In 1941 (p. 57) he listed this ant as host of this same eucharid.

Camponotus ligniperdus (Latreille)

Adlerz, 1886, Pl. VII: Fig. 7, larva in side view; Fig. 8, branched hair (repeated Escherich, 1906, Fig. 32 and 1917, Figure 38A); Fig. 8*a*, tip of uncinate hair; Figs. 10, 11, and 12 deal with internal anatomy.

Eidmann, 1926;—Fig. 3 on pp. 788 and 789, semidiagrammatic drawings of all the larvae of an incipient colony on eight different days between August 4 and May 29. Fig. 4 on p. 793, photograph of a queen carrying a larva. Fig. 5 on p. 794, a colony-founding queen with larvae (repeated Wheeler 1933*a*, Fig. 2.)

Emery, 1899, p. 7:—"La larva del *C. ligniperda* figurata dall'Adlerz non è ipocefala."

Mayr, 1855, p. 283:—"Mit abstehenden Haaren bekleidet, welche . . . baumförmig verzweigt sind, indem sie entweder schon am Grunde oder von diesem etwas weiter entfernt, lange Aeste austreiben."

Skwarra, 1927, p. 84:—This ant is listed as a host of the chrysomelid larva *Clytra quadripunctata* L. See under *Formica rufa*.

Camponotus pennsylvanicus (DeGeer)

Similar to *noveboracensis* except as follows: body hairs mostly bifid, a few simple, rarely trifid; uncinate hairs shorter (about 0.12 mm) and apparently replaced laterally by long simple or denticulate hairs; head hairs shorter, simple or with the tips 2 to 3-branched; anterior surface

of labrum with eight hairs and (on or near the ventral border) 12 sensilla. (Material studied: several larvae from New York and Massachusetts.)

Pricer, 1908:—The first larvae of an incipient colony "grew very rapidly, almost doubling in size in a single day, and the rate of growth decreased gradually as other larvae appeared to demand food and care. By September 1, the change in size was scarcely perceptible in a week's time" (p. 179). The life cycle in an incipient colony was found to be: egg 24 days, larva 21 days, pupa 21 days, total 66 days (p. 180). "In outdoor nests some larvae spend the winter in a state of arrested development, and I have kept one colony. . . in an artificial nest all winter in the insectory and no growth could be noticed in the larvae until about March 1, when they suddenly began to grow at about the usual summer rate" (p. 180). The number of larvae in incipient colonies varied from eight to 32 (Table I, p. 183). The number of larvae in established colonies ranged from 74 to 867 (Table III on p. 185). The relation of number of larvae to colony size was discussed on pages 187 and 192.

Schneirla & Chace, 1951:—The photographs on pages 228, 229, 230 and 232 include larvae.

Wheeler, 1910, Fig. 105 on p. 189: photograph of a cluster of small larvae in an incipient colony. (Repeated Emery 1915, Fig. 13; Wheeler, 1926, Fig. 33 on p. 244; Wheeler, 1928*a*, Pl. XXIX, Fig. 47.)

Camponotus pennsylvanicus ferrugineus (Fabricius)

Pricer, 1908:—The number of larvae in established colonies ranged from 75 to 1330 (Table IV on p. 185). The relation of number of larvae to colony size was discussed on pages 187 and 192.

Tanquary, 1913, Pl. LXII Fig. 25: embryo just before hatching, showing internal anatomy.

Subgenus **Colobopsis** Mayr

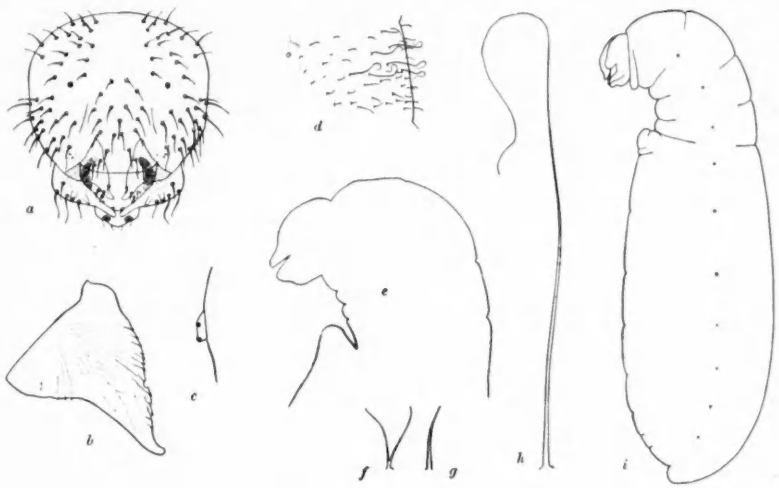
Abdomen (except somite I) subellipsoidal and rather stout; diameter greatest at the fourth and fifth abdominal somites; tapering but slightly toward the anterior end and more rapidly toward the posterior end. The praesaepium, which is formed from the depressed ventral surface of the metathorax and abdominal somite I lacks side-walls, but its posterior border is overhung by the anterior border of abdominal somite II to form a sort of pocket. Segmentation indistinct. Tenth abdominal somite forming a hemispherical button which is directed posteroventrally; anus immediately anterior to this button. Body hairs sparse, and uniformly distributed: of three types—mostly (1) simple or (2) bifid, but (3) a few very long and whip-like; none uncinate. Cranium suboctagonal in anterior view, with the corners rounded; slightly narrowed below. Antennae minute, peg-like. Head hairs short. Mandibles with only a few longitudinal ridges; some of those on the anterior surface bear minute spinules; most of those on the posterior surface bear a comb of longer spinules. Labium small; palp a slight elevation.

Camponotus (Colobopsis) mississippiensis M. R. Smith

Text fig. 2

Thorax and first abdominal somite forming a short, stout neck,

which is sharply marked off from the rest of the abdomen and which is strongly curved ventrally, so strongly, in fact, that the mouth parts may be directed posterodorsally and can even be applied to the ventral surface of the anterior abdominal somites. Rest of the abdomen subellipsoidal and rather stout; diameter greatest at the fourth and fifth abdominal somites; tapering but slightly toward the anterior end and more rapidly toward the posterior end. Adjacent to the head the prothorax bears a ventral swelling. The praesaepium, which is formed from the depressed ventral surface of the metathorax and abdominal somite I, lacks side-walls, but its posterior border is overhung



TEXT FIG. 2. *Camponotus* (*Colobopsis*) *mississippensis* M. R. Smith. *a*, head in anterior view, ×60; *b*, right mandible in anterior view, ×185; *c*, left antenna in side view, ×185; *d*, dorsal surface of abdominal somite II in side view, showing spiracle and hairs, ×44; *e*, optical section of anterior end to show praesaepium, ×28; *f* and *g*, short body hairs, ×242; *h*, long body hair, ×242; *i*, larva in side view (hairs omitted), ×20.

by the anterior border of abdominal somite II to form a sort of pocket. Segmentation indistinct. Tenth abdominal somite forming a hemispherical button which is directed posteroventrally; anus subterminal and immediately anterior to this button. Body hairs short, sparse, uniformly distributed and without alveolus or articular membrane; of three types: (1) the majority are simple or (2) 2-branched and 0.035–0.07 mm long; (3) a few very long (about 0.25 mm), whip-like hairs on the dorsa of abdominal somites II–VIII. Integument of abdominal somites VIII–X and of the ventral surface of the thorax and abdominal somites I and II with minute spinules in short transverse rows. Cranium suboctagonal in anterior view, with the corners rounded, slightly narrowed below; slightly broader than long. Head hairs numerous, short (0.036–0.054 mm); of two types: (1) mostly simple, (2) rarely 2-branched; alveolus and articular membrane present; naked

area conspicuous, in the form of an inverted V. Antennae minute, each a small peg bearing three sensilla. Labrum subparabolic in anterior view, breadth (at base) 1.5X the length; anterior surface with eight short, simple hairs and two sensilla; four projecting sensilla on the ventral border; posterior surface spinulose, the spinules minute and in rows which radiate from the dorsolateral angles, the rows continuous near the base but broken distally; posterior surface with about eight sensilla on each half; chiloscleres present. Mandibles rather small; moderately sclerotized; subtriangular in anterior view; basal third broad, somewhat thick and wedge-shaped; distal two-thirds thin, blade-like and slightly curved anteriorly; apical tooth short, smooth, round-pointed and curved medially; lateral outline saddle-shaped; middle half of mesal border denticulate; anterior surface with a few short longitudinal ridges, on some of which are mounted minute spinules; posterior surface of blade with a few longitudinal ridges, on most of which are combs of rather long spinules. Maxillae swollen ventrolaterally; apex in the form of a long and rather slender conoid which is directed ventrally and medially; mesal surface with a patch of minute spinules in short rows; palp a skewed peg bearing four apical and one lateral sensilla; galea finger-like with two apical sensilla. Labium small; anterior surface sparsely spinulose; each palp a slight elevation bearing five sensilla; opening of sericteries a transverse slit on the anterior surface. Hypopharynx densely spinulose, the spinules arranged in subtransverse rows, the rows grouped in two subtriangles which have their bases near the middle. (Material studied: seven larvae from Mississippi, collected by Dr. W. S. Creighton.)

Camponotus (Colobopsis) culmicola Wheeler

Apparently similar to ***mississippiensis***, except that the antennae have two sensilla each. (Material studied: three damaged integuments from the Bahamas.)

Camponotus (Colobopsis) gasseri Forel

Similar to ***mississippiensis***, except in the following details: Body hairs sparser; whip-like hairs much longer (about 0.5 mm); other hairs much shorter (0.009–0.027 mm). Antennae about three times as large. Anterior surface of labrum with six hairs and four sensilla. Maxillary palp finger-shaped with one of its apical sensilla large and peg-like. (Material studied: six damaged integuments from South Australia.)

Camponotus (Colobopsis) quadriceps (F. Smith)

Dahl, 1901, p. 31:—"Das Weibchen und die jungen Larven nähren sich einerseits von dem Mark [von ***Endospermum formicarum*** Becc.], andererseits von den Zellwucherungen an der Mündung und wohl auch von dem Saft, welcher an der Mündung auf fortgesetzten Reiz in geringer Menge ausfliessen dürfte."

Camponotus (Colobopsis) vitreus (F. Smith)

Emery, 1899:—"Un grado minore, ma pure ben marcato d'ipocefalia si osserva. . . Però, se si prescinde dalla forma breve e tozza e dalla posizione del capo, queste larve non differiscono notevolmente da quelle

delle altre Camponotinae. Le mandibole sono piccole e quasi interamente nascoste nell'interno della bocca; le mascelle e il labbro inferiore hanno forma ritondata; le sporgenze coniche, due per ciascuna mascella e un paio solo nel labbro inferiore, sono minute e semplici. . . . Il *C. vitreus* non forma bozzolo per metamorfosarsi; le sue pupe sono nude" (p. 7). Pl. II, Fig. 11*a*, larvae in side view; *b*, head in side view, enlarged; *c*, head in anterior view, enlarged. (Figures *b* and *c* repeated by Escherich, 1906, Fig. 31, and 1917, Fig. 37B.)

Camponotus (Colobopsis) schmitzi Stärcke

Stärcke, 1933: "Stature ordinaire des larves de *Camponotus*, cylindrique, étendue, extrémité craniale courbée de presqu'en demicercle jusque 90 degrés. Extrémité caudale projetée un peu du côté ventral, soutenant l'orifice anal. *Chaetotaxie.* Comme je ne connais pas la larve d'autres *Colobopsis*, je compare avec *Camponotus herculeanus*. La chaetotaxie des *Camponotus* comprend: (1) des acrochètes longues, bifurquées ou bifides jusque multifides, placées densément; (2) des oncochètes très longues, simples, à leur extrémité courbées en crosse. Cette chaetotaxie se retrouve chez *C. schmitzi*, avec quelques traits particuliers cependant. Les acrochètes ont leur solidité normale seulement aux extrémités craniales et caudales, sur le reste du corps ils sont fort minces, à tronçon court et fin, se ramifiant en filaments raides mais très fins et dont les extrémités sont si fines qu'on les décèle seulement en employant les objectifs d'immersion. Quelque-fois ces filaments sont capricieusement frisés, comme des chambrières. Tandis que, dans *C. herculeanus*, seulement sur la tête ces acrochètes à chambrières sont remplacées par des acrochètes plus courtes, ramifiées en tronc d'arbre bombardé, ou bien bifurquées ou bifides, dans *C. schmitzi* c'est aussi près de l'extrémité caudale qu'on trouve cette forme-là et même des acrochètes simples, présentent cependant, comme celles de la tête, à leurs sommets des traces de ramification multiple ou de la dentelure irrégulière, visibles à l'immersion. Ces acrochètes en hydre ou en tronc ramifié d'arbre bombardé de l'extrémité caudale sont beaucoup plus solides que les autres. Chez *C. herculeanus* les acrochètes de la tête sont pour la plupart encore distinctement et longuement bifurquées et longues comme la moitié de la tête, à l'exception de quelques-unes, surtout situées sur le clypéus et les parties buccales. Les oncochètes sont chez *C. schmitzi* aussi plus minces et plus flexibles (que chez *herculeanus*), en chambrière elles aussi; elles ne possèdent pas l'extrémité en crosse. A remarquer est encore qu'on trouve sur le prothorax parmi les acrochètes courtes et multifides ou ramifiées quelques acrochètes longues simples, minces et très raides. En somme les poils sont chez la larve de *C. schmitzi* particulièrement courts et flexibles, ce qu'on pourrait considerer comme une adaption aux nids dans les tiges creuses. *Pièces buccales. Mandibules* d'un point de vue frontal, peu projetées, armées d'une dent, terminale, obtuse et un peu crochue en bec de hibou. (Chez *C. herculeanus* la mandibule est grande et à dents multiples disposées en scie). Le plan dorsal porte une vingtaine de papilles solides, un peu pointues. Les sommets des papilles situées au bord interne, font un peu saillie, comme des dents fines et obtuses. Le plan inférieur porte aussi des rugosités régulières. La moitié postérieure porte dessous du

côté interne un système de rides très fines et parallèles qui s'étendent sur les deux ailes dans lesquelles la basis de la mandibule se prolonge en haut et en bas. La mandibule possède ainsi la forme d'une pyramide trilatérale à plans excavés et partout munis de dents resp. rugosités, aptes à broyer. *Maxilles* assez sveltes, tours à sensilles toutes les deux d'égale hauteur et de force égale, hautes, surpassant les mandibules. Le plan dorsal des maxilles montre sur sa moitié distale également des plis irréguliers. Cette rugosité des maxilles se rencontre rarement. *Labrum très particulier.* Ses bords droit et gauche sont largement durcis par une bande brune irrégulière de chitine, montrant quatre ou cinq rides longitudinales fines. Contre ce renfort le plan supérieur de la mandibule peut frotter. Le bord antérieur présente une deuxième particularité: il porte auprès du milieu deux papilles à sensilles de chaque côté, munies chacune d'un fort nerf sensible avec apparatus ganglionnaire. Je n'ai jamais remarqué ces papilles-là chez les autres larves de fourmis, qui les possèdent seulement sur le labium, une de chaque côté, ce qui est d'ailleurs également le cas chez *C. schmitzi.* On peut supposer pue l'innervation sensible extraordinaire du labrum chez *C. schmitzi* se rapporte à sa fonction d'apparat broyeur chez cette espèce. Les courts muscles clipéo-labraux médians sont fortement développés. *Labium* n'offre rien d'extraordinaire.. . *Trophorhinium* extraordinairement développé; plis inclinés vers l'extérieur, sa prolongeant un peu sur la maxille. Dessous du labrum avec quelques plis semblables, également inclinés en avant" (pp. 30–31). Internal anatomy p. 31. Photomicrographs of larva [semipupa ?] in profile, Fig. 4; of anterior end of same enlarged, Fig. 5; of labrum, Fig. 6; of the "bord chitineuse du labrum," Fig. 7; of the mouth parts in side view, Fig. 8 [the outline of the mandible seems to be inaccurate]; of mouth parts in anterior view, Fig. 9; of an antenna, Fig. 10; of "trophorhinium" [hypopharynx ?] in profile, Fig. 11; hypopharynx, Fig. 12; "fines rides du plan inférieur de la mandibule" [hypopharynx?], Fig. 13.

Camponotus (Colobopsis) sp.

Hutchins (1935, p. 172) described the larvae as "white and spindle-shaped, smaller at one end than the other."

Subgenus **Myrmamblys** Forel

Camponotus (Myrmamblys) vividus (F. Smith)

Similar to *noveboracensis* except as follows: head hairs about half as numerous; anterior surface of labrum with about 12 hairs and (on or near the ventral border) 12 sensilla; distal half of mandibles narrower and straight. (Material studied: damaged integuments of five heads and a part of one body from the Congo.)

Subgenus **Myrmaphaenus** Emery

Camponotus (Myrmaphaenus) novogranadensis Mayr

Plate V, fig. 14

Similar to *noveboracensis* except as follows: Praesaepium better developed and apparently permanent; the posterior half of the ventral surface of abdominal somite II is raised to form a transverse welt and,

on either side, ridges from this welt extend forward to form the sides of the praesaepium. The floor of the praesaepium (and also the ventral surface of the first abdominal somite and of the thorax) is furnished with short transverse rows of minute spinules. Only about seven differentiated somites. Body hairs 2 to 4-branched, length 0.036–0.12 mm, a few with alveolus and articular membrane; no uncinate hairs. Head hairs shorter. Anterior surface of labrum with seven or eight hairs and about ten sensilla; six projecting sensilla on the ventral border. Maxillary palp longer and conical, with four apical and one lateral sensilla; galea digitiform, with two apical sensilla. (Material studied: numerous larvae from the Panama Canal Zone.)

In the newly hatched larva (length about 1 mm; the egg is 0.75 mm long) the thorax and abdominal somites I, II, VIII, IX and X bear many 1-hooked uncinate hairs (about 0.072 mm long), which have alveoli and articular membranes; these somites are also moderately well supplied with shorter (0.018–0.054 mm) 1 to 4-branched hairs, some with, some without alveoli and articular membranes. Abdominal somites III-VII are nearly naked but do have a few short (0.027–0.054 mm) simple hairs, which have alveoli and articular membranes. The five anterior somites are more distinct than the others. Most head hairs are uncinate, with denticulate shaft, about 0.072 mm long; there are also a few 1 to 3-branched hairs, about 0.05 mm long; all head hairs have alveoli and articular membranes.

Subgenus **Myrmentoma** Forel

Camponotus (Myrmentoma) nearcticus Emery

(Plate V, figs. 15–16)

Similar to *noveboracensis* except for the following details: Praesaepium as in *novogranadensis*. About six differentiated somites. Body hairs shorter (0.035-0.07 mm); no uncinate hairs on abdominal somites IX and X; uncinate hairs and a few of the branched hairs with alveolus and articular membrane. Head hairs shorter (0.054-0.1 mm); mostly simple and whip-like; a few 2-branched. Anterior surface of labrum with about ten hairs and six small sensilla; ventral border with six projecting sensilla. (Material studied: numerous larvae from Texas.)

Subgenus **Myrmeurynota** Forel

Camponotus (Myrmeurynota) linnaei Forel

Similar to *noveboracensis* except for the following details: Praesaepium similar to that of *novogranadensis*. Branched body hairs shorter (0.054–0.072 mm), without alveolus or articular membrane; on abdominal somites VIII-X about a third of the hairs are denticulate and 0.07–0.1 mm long; all other somites have each a few denticulate hairs about 0.08 mm long; a few of the denticulate hairs have alveolus and articular membrane; apparently no uncinate hairs. Cranium transversely subelliptical in anterior view. Head hairs more numerous; of two types: (1) 2 to 3-branched, about 0.035 mm long and (2) denticulate, about 0.07 mm long. Anterior surface of labrum with eight hairs and four small sensilla; ventral border with six projecting sensilla.

Maxillary palp a subcone bearing four apical and one lateral sensilla; galea finger-like. (Material studied: several larvae from Panama and from the Panama Canal Zone.)

Subgenus **Myrmobrachys** Forel

Camponotus (Myrmobrachys) planatus Roger

Similar to *noveboracensis* except for the following details: Praesaepium similar to that of *novogranadensis*. Body hairs of three types: (1) mostly 2 to 4-branched, 0.036–0.13 mm, without alveolus and articular membrane; (2) the thoracic and abdominal somites VIII-X have each a few denticulate hairs, about 0.09 mm long; (3) on each of the other abdominal somites there are a few uncinate hairs, about 0.16 mm long; types (2) and (3) have alveoli and articular membranes. Head hairs of three types: (1) simple, (2) denticulate, and (3) 2 to 3-branched; 0.035–0.1 mm long. Anterior surface of labrum with ten hairs and 2 to 4 small sensilla; ventral border with six projecting sensilla. Maxillary palp a cone, with four apical and one lateral sensilla; galea finger-like, with two apical sensilla. (Material studied: numerous larvae from Cuba.)

Camponotus (Myrmobrachys) brevis obscurifrons Santschi

Similar to *planatus*. (Material studied: numerous larvae from the Panama Canal Zone.)

Camponotus (Myrmobrachys) canescens Mayr

Similar to *planatus*. (Material studied: several larvae from Panama)

Camponotus (Myrmobrachys) formiciformis Forel

Wheeler, 1915, p. 332:—"Although I did not see the larvae in the act of being used as shuttles in the construction of the [silken] nest, there can be no doubt that they are thus employed. The pupae were all enclosed in white cocoons like those of other small species of *Camponotus*." The workers are monomorphic; see under *senex* below.

Camponotus (Myrmobrachys) senex (F. Smith)

Forel (1905, p. 170), referring to this species and its subspecies *textor* Forel:—"Die Ameisen bauten weitere Nebennester, indem sie ihre spinnenden Larven im Maul hielten, und dieselben in Zick-Zack-Linie hin und her bewegten, sodass von innen heraus das feine und dichte Gewebe entstand und, Gänge und Kammern bildend, immer weiter ausgedehnt wurde." (Referred to by Bischoff, 1927, pp. 304–305; Brun, 1924, p. 57; Emery, 1925, p. 162; Forel, 1923, pp. 99–100 = 1928, Vol. II, pp. 281-282; Wheeler, 1915, p. 331.) Wheeler also stated that the workers were "practically monomorphic, so that it would seem that the habit of employing the larvae for spinning the nest tends to make them develop into adults of uniform stature and shape. It is not easy to understand why this should follow." (p. 332). "More mature larvae are used as shuttles and the cocoon-spinning instincts have not been suppressed" (p. 333).

Camponotus (Myrmobrachys) zoc Forel

Similar to *planatus*. (Material studied: numerous larvae from the Panama Canal Zone.)

Subgenus **Myrmocladoecus** Wheeler

Camponotus (Myrmocladoecus) latangulus Roger

Similar to *noveboracensis* except for the following details: Body hairs of three types: (1) mostly 2 to 4-branched, 0.054–0.09 mm long; (2) simple, 0.07–0.09 mm long, a few on each thoracic somite and many on abdominal somites VIII-X; (3) one-hooked uncinate hairs, about 0.19 mm long, a few on the dorsa of each of the abdominal somites I-VII; alveolus and articular membrane present in the second and third types. Head hairs short (0.054–0.08 mm); of two types: (1) simple and (2) bifid. Anterior surface of labrum with nine hairs and four small sensilla; ventral border with six projecting sensilla. Maxillary palp digitiform, with four apical and one lateral sensilla; galea digitiform with two apical sensilla. (Material studied: four damaged integuments from British Guiana.)

Subgenus **Myrmophyma** Forel

Camponotus (Myrmophyma) aeniopilosus Mayr

Similar to *noveboracensis* except as follows: Praesaepium similar to that in *novogranadensis*. Body hairs of two types; (1) mostly 2 to 4-branched, 0.054–0.07 mm long, without alveolus and articular membrane; (2) on each somite are a few longer hairs (0.11–0.16 mm),which are simple, branched or denticulate and have aveoli and articular membranes. Head hairs more numerous, shorter (0.054–0.09 mm) and of three types: (1) simple, (2) denticulate, (3) 2 to 3-branched. Anterior surface of labrum with ten hairs and ten sensilla; ventral border with four projecting sensilla. Apical tooth of mandible more slender and nearly twice as long. Maxillary palp a frustum bearing four apical and one lateral sensilla; galea digitiform. (Material studied: three integuments from Queensland.)

Camponotus (Myrmophyma) claripes piperatus Wheeler

Wheeler (1933*b*) described a mermithergate of this ant and inferred that the ant larva had been parasitized by the nematode larva.

Subgenus **Myrmosphincta** Forel

Camponotus (Myrmosphincta) sexguttatus (Fabricius)

Similar to *noveboracensis* except for the following details: Praesaepium similar to that in *novogranadensis*. Body hairs of six types: mostly (1) 2 to 4-branched, 0.036–0.054 mm long; a few (2) simple or (3) denticulate hairs which are 0.07–0.1 mm long; a few (4) simple or (5) denticulate hairs, 0.11–0.16 mm long, on thorax and abdominal somite I and VIII-X; (6) a few uncinate hairs, 0.11–0.16 mm long, on abdominal somites II-VII; types (1), (2), and (3) do not have alveolus and articular membrane, the other types have these structures. Head hairs shorter (0.036–0.13 mm), of three types: (1) simple, (2) denticulate,

(3) 2 to 3-branched. Anterior surface of labrum with eight hairs and four small sensilla; ventral border with six projecting sensilla. Maxillary palp digitiform, with three apical and two lateral sensilla. (Material studied: numerous larvae from Puerto Rico, British Guiana and the Panama Canal Zone.)

Subgenus **Myrmothrix** Forel

Camponotus (Myrmothrix) abdominalis (Fabricius)

Similar to *noveboracensis* except in the following details: Praesaepium similar to that in *novogranadensis*. Body hairs of two types: (1) mostly 2- to 7-branched, about 0.07 mm long; (2) denticulate hairs, about half as numerous, 0.072–0.11 mm long; all without alveolus or articular membrane. Head hairs of two types: (1) mostly denticulate, 0.07–0.16 mm long; (2) about six 3 to 4-branched hairs, about 0.07 mm long. Anterior surface of labrum with ten hairs and eight sensilla; ventral border with six projecting sensilla. Maxillary palp digitiform, with three apical and two subapical sensilla; galea digitiform. (Material studied: several larvae from the Panama Canal Zone.)

Camponotus (Myrmothrix) abdominalis stercorarius Forel

Very similar to *abdominalis*, but with the body hairs slightly longer (0.07–0.18 mm) and the head hairs slightly shorter (0.05–0.11 mm) and somewhat more numerous. (Material studied: numerous larvae from Panama.)

Wheeler (1933*b*) described a mermithergate of this ant and inferred that the larva had been parasitized by the nematode larva.

Subgenus **Myrmotrema** Forel

Camponotus (Myrmotrema) foraminosus Forel

Similar to *noveboracensis* except as follows: Praesaepium similar to that of *novogranadensis*. Body hairs of three types; (1) mostly 2 to 4-branched, 0.054–0.07 mm long, without alveolus and articular membrane; (2) a few longer hairs (about 0.1 mm) on the thorax and abdominal somites VIII-X are simple or denticulate or branched; (3) the few one-hooked uncinate hairs on abdominal somites I-VII are 0.12–0.14 mm long; types (2) and (3) have alveolus and articular membrane. Head hairs more numerous and of three types: (1) simple, (2) denticulate and (3) branched. Anterior surface of labrum with about 11 hairs and two small sensilla; ventral border with six projecting sensilla. Maxillary palp digitiform, with four apical and one lateral sensilla; galea digitiform. (Material studied: three integuments; source unknown.)

Subgenus **Tanaemyrmex** Ashmead

Camponotus (Tanaemyrmex) sansabeanus (Buckley)

Similar to *noveboracensis* except in the following details: Praesaepium similar to that in *novogranadensis*. Body hairs of two types: (1) 2 to 4-branched, 0.09–0.11 mm long, without alveolus or articular membrane, the most numerous type; (2) a few 2 to 4-branched, 0.12–0.14 mm long, with alveolus and articular membrane. Entire integu-

ment spinulose, the spinules minute and in short transverse rows. Head hairs shorter (0.07–0.11 mm). Anterior surface of labrum with 11 hairs and six sensilla; ventral border with six projecting sensilla. Mandibles with the apical tooth distinctly narrower and longer. Maxillary palp with one projecting apical, three subapical and one lateral sensilla; galea digitiform. (Material studied: numerous larvae from Oklahoma.)

Camponotus (Tanaemyrmex) simillimus indianus Forel

Similar to *noveboracensis* except in the following details: Praesaepium similar to that in *novogranadensis*. Body hairs of three types: (1) numerous, 2 to 4-branched, 0.07–0.11 mm long; (2) numerous, simple, 0.11–0.14 mm long; (3) few, denticulate, 0.11–0.19 mm long; alveolus and articular membrane are lacking except in the longer denti culate hairs. Head hairs of three types: (1) simple, (2) denticulate, (3) branched. Anterior surface of labrum with nine hairs and four sensilla; ventral border with six projecting sensilla. Maxillary palp digitiform, with two apical, two subapical and one lateral sensilla; galea digitiform. (Material studied: numerous larvae from the Panama Canal Zone.)

Camponotus (Tanaemyrmex) aegyptiacus Emery.

"Des mandibules relativement peu développées, des poils ramifiés sur la tête. L'orifice salivaire est bien visible. Sur le corps, poils ramifiés particuliers" (Athias-Henriot, 1947, pp. 251–252).

Camponotus (Tanaemyrmex) aethiops (Latreille)

Parker (1932) recorded this ant as the host of *Stilbula cynipiformis* Rossi in France. The eucharid larvae were parasitic on the ant larvae and pupae. An ant larva bearing a planidium is shown in side view in Fig. 1 on p. 3. This same eucharid has also been reported with these ants: *Camponotus marginatus* (Latreille) by Fahringer and Tolg, 1912, p. 250; *Camponotus maculatus sanctus* Forel by Fahringer, 1922; *Camponotus maculatus* F. in Dalmatia by Ruschka, 1924, p. 89. Probably all three are *aethiops*.

Camponotus (Tanaemyrmex) aethiops concava Forel

Menozzi, 1936:—"Descrivo la larva adulta di questo *Camponotus:* Essa è di colore biancastro, col capo ocraceo, le mandibole quasi del tutto testacee, eccettuato una porzione apicale più scura. Setole biancastre. La forma generale del corpo è subclaviforme, coi segmenti tutti distinti. Il capo visto di lato appare molto più alto che lungo. Guardato dorsalmente il cranio è ristretto in avanti, coi margini laterali subarrotondati e convergenti anteriormente, il margine posteriore è cubtroncato, la sua superficie è provvista di numerose setole distribuite some nella figura citata. Placchette antennali ovali, fornite, ciascuna, di tre sensilli. Il labbro superiore ha la forma di un semicerchio, rinforzato per ciascun lato, alla base, da un ispessimento fortemente chitinizzato, mentre al margine anteriore si trova un gruppo di tre grosse papille sporgenti oltre il margine stesso. Sulla superficie dorsale esso è provvisto di otto setolette delle quali, due, poste ai lati ed a metà della linea mediana longitudinale, mentre le altre sei, divise in due

gruppi di tre setole, sono collocate immediatamente al disopra delle papille sopracitate; ventralmente ha diversi sensilli e numerose produzioni tegumentali spiniformi, i primi distribuiti lungo il margine anteriore, le altre in quasi tutta la superficie mediana e sublaterale. le mandibole sono un poco più lunghe della loro larghezza prossimale, di forma triangolare, coll'apice subacuto e alquanto ricurvo verso l'interno; il margine masticatorio è tagliente e provvisto di una leggera prominenza odontoide posta alla base del terzo anteriore. Le mascelle hanno ognuna quattro setolette, poste posteriormente ed ai lati dell'appendice distale mascellare e del palpo. Questi è un poco più breve e più sottile dell'appendice, del resto di forma simile a quest'-ultima, ed entrambi forniti all'apice di tre sensilli placoidei. Il labbro inferiore è sempre più sporgente del labbro superiore e, come questo, ha forma semicircolare e fornito di due setolette situate come si vede nella figura citata. I palpi labiali sono rappresentati ciascuno da un articolo subconico, molto più breve, ma più grosso, del palpo mascellare, e provvisti anch'essi all'apice di tre sensilli. Fra i palpi labiali, un poco più posteriormente ad essi, sorgono i due piccoli tubuli delle filiere. Tutto il corpo della larva ha una fitta pubescenza formata da peli bifidi, trifidi o, più raramente, quadrifidi. Sistema tracheale olopneustico con 10 paia di spiracoli. Lunghezza della larva adulta mm. 7, 3-7,8" (pp. 301–302). Fig. XVIII, p. 301; larva in side view; head in anterior view; branched hairs.

Camponotus (Tanaemyrmex) aethiops andria Forel

Menozzi, 1936:—"Descrizione della larva adulta:—Forma, colore e pubescenza eguale a quella della larva del *C. aethiops* v. *concava*. Il cranio visto dal dorso presenta una forma pressapoco simile a quella della larva ora citata, con setole distribuite come appare nella figura XIX, 1. Le placchette antennali sono subtriangolari, più lunghe che larghe, ognuna con tre sensilli. Il labbro superiore visto ad un forte ingrandimento, appare di forma trapezoidale, coi lati subarrotondati e rinforzati, ciascuno, da un ispessimento chitinizzato del tutto simile a quello che si osserva nella larva del *C. aethiops* v. *concava*. Dorsalmente, in avanti, esso è fornito di 8 setole, due submediane, le altre sei sono divise in due gruppi di tre setole, distribuite fra la setola submediana e l'ispessimento chitinizzato. Dietro a ciascun gruppo di queste setole è posto un sensillo papilliforme, che non sono riuscito a rintracciare nella larva del *C. aethiops* v. *concava*, mentre in prossimità del margine anteriore del labbro, a ciascuno dei lati della linea mediana longitudinale, si trova un gruppo di tre sensilli placoidei. Ventralmente è provvisto delle solite formazioni tegumentali e di sensilli, e delle sei grosse papille, divise in due gruppi di tre, che sporgono oltre il margine anteriore. Le mandibole sono robuste, più lunghe che larghe col margine masticatorio, visto dal dorso, semplicemente tagliente e coll'apice ottuso e leggermente ricurvo verso l'interno; ventralmente, nella porzione mediana, esse presentano una serie di lamine chitinizzate, poste ad embrice, e delle quali alcune sporgono colla loro punta oltre il margine masticatorio inferiore, in modo che, viste dal dorso, si potrebbero dire armate da una serie di piccoli denti. Le mascelle hanno lo stipite terminato da un grosso mucrone il quale generalmente nella prepara-

zione in toto del capo rimane nascosto sotto il labbro inferiore: dorsalmente esse sono provviste di tre setole, mentre al ventre ne hanno un numero maggiore e distribuite come si vede nella figura citata. Il processo distale delle mascelle ed il palpo sono piuttosto gracili, il primo più lungo del secondo e forniti entrambi all'apice di tre sensilli. Il labbro inferiore e fortemente trasverso e provvisto di 8 setole, delle quali 6 sparse nella superficie centrale, ed una per ogni lato del margine anteriore. I palpi labiali sono subcilindrici, poco più lunghi che larghi e provvisti all'apice di tre sensilli, simili a quelli dei palpi mascellari. Tubi delle filiere di forma triangolare e connessi tra di loro da una sottile banderella sclerificata. Lunghezza della larva matura mm. 7, 5–8" (pp. 302–303). Fig. XIX, p. 303: head in anterior view; labrum in anterior view; mandible in posterior view; maxillae and labium in posterior view; labium in anterior view.

Camponotus (Tanaemyrmex) compressus foleyi Santschi

Athias-Henriot, 1947: internal anatomy—pp. 253, 254, 256, 260, 263, 264 and 266 and Fig. 4 on p. 262; "Surtout carnivore" (p. 260).

Camponotus (Tanaemyrmex) consobrinus Erichson

Wheeler (1933*b*) described mermithergates of this ant and inferred that the ant larvae had been parasitized by the nematode larvae.

Camponotus (Tanaemyrmex) fumidus vittata Forel

"Die älteren Larven sind von einem dichten Pelz verzweigter Haare bedeckt, der dem ersten Larvenstadium noch fehlt" (Eidmann, 1936, p. 93).

Camponotus (Tanaemyrmex) pompeius cassius Wheeler

Wheeler (1928*b* and 1929*b*) described a mermithergate of this ant and inferred that its larva had been parasitized by the nematode larva.

Camponotus (Tanaemyrmex) punctulatus minutior Forel

Wheeler (1929*b* and 1933*b*) described a mermithergate of this ant and inferred that its larva had been parasitized by the nematode larva.

Camponotus (Tanaemyrmex) sylvaticus barbaricus Emery

Athias-Henriot, 1947:—"Le corps de la larve est allongé et présente une courbure très accentuée au niveau du troisième segment thoracique, de sorte que la tête et une bonne partie du thorax sont repliées et appliquées contre la face ventrale de l'abdomen. La tête est bien différenciée, relativement volumineuse, massive. Les mandibules sont très développées. On peut y distinguer deux parties: [1] Une zone masticatrice incolore ou peu colorée, portant de fortes dents sur son bord interne. Ces dents sont émoussées, mais sont pourvues sur un côté de fines denticulations pectinées. [2] Le bord externe très épais, arqué, pointu, coloré en brun; il se sépare en deux branches insérées profondément dans la tête. Du niveau de la base de cette mandibule, de chaque côté, partent des lames chitineuses striées qui forment une voûte pharyngienne (épipharynx). Les maxilles sont des mamelons peu proéminents portant deux grands palpes. Le labium

porte l'orifice salivaire médian et deux petits palpes. Au niveau de la bouche, on voit des ornementations particulières, qui se continuent par le plancher du pharynx. C'est alors l'hypopharynx. Toute la tête porte des macrochètes simples, peu nombreux. Les anneaux thoraciques et abdominaux (7) sont bien visibles et séparés par des constrictions. Tout le corps porte des macrochètes simples, nombreux, et le thorax, des macrochètes ramifiés" (pp. 250–251). Internal anatomy: pages 257, 260, 263 and 264, "Surtout carnivore" (p. 260).

Gantes, 1949:—"Ce sont de très grosses larves, dépassant 1 cm., mais les jeunes larves n'ont que 2 mm. L'aspect général du corps est celui de *Plagiolepis*, plus massif cependant que les trois précédents. Le corps est recouvert de poils ramifiés surtout, les poils simples sont plus rares: 1. *Poils ramifiés* mesurant 0 mm. 116; ils s'élèvent audessus de la peau par un tronc court et épais divisé en 2 ou 3 troncs secondaires qui à leur tour donnent des branches très fines à l'extrémité. Ces poils, vers le bout de l'abdomen, sont en rangs transversaux et longitudinaux. 2. *Poils simples*, raides, légèrement arqués, de 0 mm. 073, clairsemés sur tout le corps. La tête est massive, même forme que chez *Plagiolepis*, avec labre à un seul lobe qui porte huit poils dorsalement: trois presque vers le milieu et en avant et un en arrière pour chaque moitié. Ventralement sur le bord antérieur, on a six papilles sensorielles à une sensille chacune: au milieu sont les deux plus hautes et diminuent de chaque côté. Les mandibules sont grandes, 0 mm. 147: ce sont des triangles massifs dont la base s'insère dans la tête et l'apex se termine par une pointe émoussée; convexes extérieurement, légèrement creusées à la partie interne qui est garnie de dents émoussées en rangs verticaux. Les autres pièces buccales n'ont rien de particulier. La tête est recouverte de poils ramifiés dont le tronc principal s'élève plus haut avant de se diviser en quatre branches au plus. Ils mesurent 0 mm. 119. Chez une jeune larve, on trouve des *poils en crosse* de 0 mm. 161 de long, répartis dorsalement sur les segments abdominaux. Sur la tête on trouve des poils simples, très longs, 0 mm. 124, des poils bifurqués plus courts, 0 mm. 069. Les mandibules, de 0 mm. 064, sont très claires, plus massives et n'ont qu'une rangée de dents émoussées" (p. 78). Pl. II, fig. IV: labrum, mandible and hairs.

Genus **Calomyrmex** Emery

Cranium transversely subelliptical in anterior view. Antennae moderately large. Gula spinulose. Head hairs moderately long. Mandibles with numerous longitudinal ridges, some of which bear minute spinules. Maxillary palp a tall frustum; galea similar. Labial palp a low knob.

Calomyrmex albopilosus (Mayr)

Plate VI, figs. 1–6

Body shape probably as in *Camponotus s. str.* Praesaepium probably more like that of *C.* (*Myrmaphaenus*) *novogranadensis*. Body densely and uniformly covered with short hairs, except on the ventral surface of the thorax and abdominal somites I and II where they become sparse. Hairs of four types: (1) 1 to 7-branched, the simple hairs restricted

to the ventral surface of the thorax and abdominal somites I and II, length 0.09–0.13 mm, without alveolus and articular membrane, the most numerous type; (2) 2 to 4-branched, hairs about 0.13 mm long, a few on the thorax and abdominal somite I, with alveolus and articular membrane; (3) a few denticulate, about 0.2 mm long, on abdominal somites VII–X, with alveolus and articular membrane; (4) a few one-hooked uncinate hairs on abdominal somite II-VI, about 0.29 mm long, with alveolus and articular membrane. Integument of abdominal somite X and ventral surface of thorax and abdominal somites I and II spinulose, the spinules minute and in short transverse rows. Cranium transversely subelliptical in anterior view, breadth 1.5X the length; gula with short transverse rows of minute spinules. Head hairs numerous, moderately long (0.054–0.13 mm), mostly simple, a few 2-branched, with alveolus and articular membrane; naked area conspicuous in the form of an inverted V. Antennae with three sensilla each. Labrum subparabolic in anterior view; breadth (at base) 1.4X the length; anterior surface with eight simple hairs and four sensilla; ventral border with six slightly projecting sensilla; posterior surface spinulose, the spinules minute and arranged in rows which radiate from the dorsolateral angles, the rows continuous near the base but broken distally; posterior surface with about 20 sensilla; chiloscleres present. Mandibles rather small; moderately sclerotized; subtriangular in anterior view; basal third broad, somewhat thick and wedge-shaped; distal two-thirds thin and blade-like; apical tooth smooth, round-pointed and curved medially; lateral outline saddle-shaped; middle half of mesal border denticulate; anterior and posterior surfaces roughened with numerous longitudinal ridges, on some of which are mounted minute spinules. Maxillae swollen ventrolaterally; apex in the form of a cone which is directed medially; mesal surface spinulose, spinules minute and in short longitudinal rows; palp a tall frustum, with four apical and one lateral sensilla; galea a taller frustum with two apical sensilla. Labium with the anterior surface spinulose, the spinules minute and in short transverse rows; palp a low peg, with five sensilla; opening of sericteries wide and salient, with two projections. Hypopharynx densely spinulose, the spinules arranged in subtransverse rows, the rows grouped in two subtriangles which have their bases near the middle. (Material studied: three damaged integuments from Queensland.)

Calomyrmex splendidus purpureus (Mayr)

Brues (1934, p. 207) recorded *Schizaspidia calomyrmecis* Brues "still enclosed in the cocoon" of this ant from West Australia; the eucharid larvae were probably parasitic on the ant larvae.

Genus **Dendromyrmex** Emery

Uncinate hairs lacking. Cranium transversely subelliptical in anterior view. Antennae small. Head hairs moderately long. Mandibles with numerous longitudinal and transverse ridges, some of which bear minute spinules. Maxillary palp a tall frustum; galea finger-like. Labial palp a skewed peg.

Dendromyrmex fabricii pictus Wheeler

Plate VI, figs. 7–11

Body-shape probably as in *Camponotus s. str.* Praesaepium probably more like that of *C.* (*Myrmaphaenus*) *novogranadensis.* Body densely and uniformly covered with short hairs except on the ventral surface of the thorax and abdominal somites I and II where they become sparse. Hairs of three types: (1) 2 to 4-branched, 0.09–0.13 mm long, without alveolus or articular membrane, the most numerous type; (2) a few 2-branched hairs on each thoracic somite, about 0.11 mm long, with alveolus and articular membrane; (3) a few simple slightly curved hairs on each abdominal somite, about 0.14 mm long, with alveolus and articular membrane. Integument of the posterior abdominal somites and of the ventral surface of the thorax and abdominal somites I and II with minute spinules in short transverse rows. Cranium transversely subelliptical, breadth 1.4X the length. Head hairs numerous, moderately long (0.054–0.14 mm), mostly denticulate, a few branched; with alveolus and articular membrane; naked area conspicuous in the form of an inverted V. Antennae small, each mounted on a low convexity and bearing three sensilla. Labrum subparabolic in anterior view; breadth (at base) 1.5x the length; anterior surface with seven simple hairs and eight small sensilla; ventral border with six projecting sensilla; posterior surface spinulose, the spinules minute and in rows which radiate from the dorsolateral angles, the rows continuous near the base but broken distally; posterior surface with about 20 sensilla; chiloscleres present. Mandibles rather small and moderately sclerotized; basal third somewhat thick and wedge-shaped; distal two-thirds thin and blade-like; apical tooth short, smooth, round-pointed and curved medially; lateral outline saddle-shaped; middle half of mesal border denticulate; anterior and posterior surfaces with numerous longitudinal and subtransverse ridges, some of which bear minute spinules. Maxillae swollen ventrolaterally; apex in the form of a cone which is directed medially; mesal surface spinulose,

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EXPLANATION OF PLATE VI

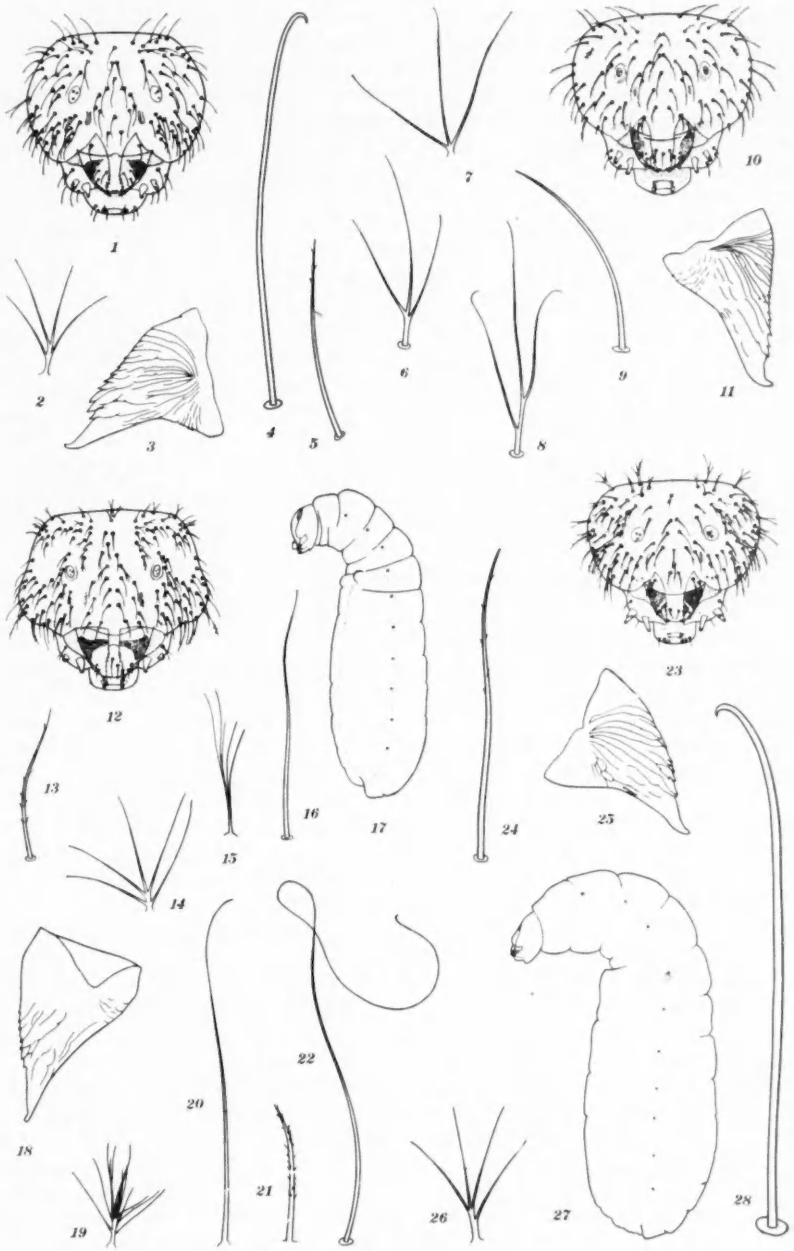
Calomyrmex albopilosus (Mayr). FIG. 1. Head in anterior view, ×40. FIG. 2. Branched body hair, ×185. FIG. 3. Left mandible in anterior view, ×118. FIGS. 4–6. Three body hairs with alveolus and articular membrane, ×185.

Dendromyrmex fabricii pictus Wheeler. FIG. 7. Branched body hair, ×235. FIGS. 8 and 9. Two body hairs with alveolus and articular membrane, ×235. FIG. 10. Head in anterior view, ×40. FIG. 11. Right mandible in anterior view, ×118.

Polyrhachis (*Chariomyrma*) *hookeri* Lowne. FIG. 12. Head in anterior view, ×44. FIG. 13. Denticulate hair, ×185. FIG. 14. Branched body hair, ×185. FIG. 15. The same in edge view, ×185. FIG. 16. Simple body hair, ×185. FIG. 17. Larva in side view (hairs omitted), ×10. FIG. 18. Left mandible in anterior view, × 118.

Polyrhachis (*Myrma*) *gagates* F. Smith. FIGS. 19–22. Four body hairs, ×95.

Echinopla sp. FIG. 23. Head in anterior view, ×36. FIG. 24. Denticulate body hair, ×235. FIG. 25. Right mandible in anterior view, ×118. FIG. 26. Branched body hair, ×235; FIG. 27. Larva in side view (hairs omitted), ×10. FIG. 28. Uncinate body hair, ×235.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the spinules minute and in short longitudinal rows; palp an elongate frustum, with two apical, two subapical and one lateral sensilla; galea finger-like, with two apical sensilla. Labium with anterior and posterior surfaces roughened with short transverse rows of minute spinules; palp a skewed peg bearing four apical and one lateral sensilla; opening of sericteries wide and salient, with two projections. Hypopharynx densely spinulose, the spinules minute and arranged in subtransverse rows, the rows grouped in two subtriangles which have their bases near the middle. (Material studied: three damaged integuments from Brazil.)

Genus **Echinopla** F. Smith

Abdomen (except somite I) subellipsoidal and rather stout; diameter greatest at the sixth abdominal somite; tapering but slightly toward the anterior end and more rapidly toward the posterior end. Anus terminal with a conspicuous posterior lip. Cranium subtrapezoidal in anterior view, narrowed below, with the dorsal angles broadly rounded. Antennae small. Head hairs rather short. Mandibles with numerous longitudinal ridges, some of which bear minute spinules. Maxillary palp a slender subcone, as long as the galea, which is finger-like. Labial palp a short peg.

Echinopla sp.

Plate VI, figs. 23–28

Thorax and first abdominal somite forming a short stout neck, which is sharply marked off from the rest of the abdomen and which is strongly curved ventrally. Rest of abdomen subellipsoidal and rather stout; diameter greatest at the sixth abdominal somite; tapering but slightly toward the anterior end and more rapidly toward the posterior end. Praesaepium well developed and apparently permanent;; the posterior half of abdominal somite II is raised to form a transverse welt and, on either side, ridges extend forward from this welt to form the sides of the praesaepium. The floor of the praesaepium (and also the ventral surface of the first abdominal somite and of the thorax) is furnished with short transverse rows of minute spinules. Posterior end rounded; anus terminal, with a conspicuous posterior lip. Thirteen differentiated somites. Body densely and uniformly covered with short hairs, except on the ventral surface of the thorax and abdominal somites I and II where they become sparse. Hairs of three types: (1) 4 to 6-branched, 0.09–0.12 mm long, without alveolus and articular membrane, the most abundant type; (2) denticulate, 0.11–0.19 mm long, with alveolus and articular membrane, most numerous on the prothorax and abdominal somites VIII-X; (3) long (about 0.3 mm) one-hooked uncinate hairs, with alveolus and articular membrane, a few each on the dorsal and lateral surfaces of abdominal somites II-V. Cranium subtrapezoidal in anterior view but with the dorsal angles broadly rounded; narrowed ventrally; breadth 1.4X the length. Head hairs rather short (0.054–0.11 mm); numerous; of three types-(1) simple, (2) denticulate, (3) 2 to 4-branched; alveolus and articular membrane present. Antennae small, mounted on low convexities,

with three sensilla each. Labrum subparabolic in anterior view; anterior surface with seven short simple hairs and six sensilla; ventral border with six projecting sensilla; posterior surface spinulose, the spinules minute and arranged in rows which radiate from the dorsolateral angles, the rows continuous near the base but broken distally; posterior surface with about 20 sensilla; chiloscleres present. Mandibles rather small; moderately sclerotized; subtriangular in anterior view; basal third broad, somewhat thick; distal two-thirds thin, blade-like and slightly curved anteriorly; apical tooth smooth round-pointed and curved medially; lateral outline saddle-shaped; middle half of mesal border denticulate; anterior and posterior surfaces with longitudinal ridges, some of which bear minute spinules. Maxillae swollen ventrolaterally; apex in the form of a cone which is directed medially; mesal surface with minute spinules in longitudinal rows; palp a slender subcone as long as the galea, with two apical and three lateral sensilla; galea digitiform, with two apical sensilla. Labium with the anterior surface spinulose, the spinules minute and in short transverse rows; palp a short peg bearing five sensilla. Hypopharynx densely spinulose, the spinules arranged in subtransverse rows, the rows grouped in two subtriangles which have their bases near the middle. (Material studied; 12 larvae labelled "Lampongs, Wai Lima, S. Sumatra, Karny & Siebers.")

Genus **Polyrhachis** F. Smith

Cranium subtrapezoidal in anterior view, narrowed above. Antennae small. Gula spinulose. Head hairs moderately long. Mandibles with only a few longitudinal ridges, some of which bear minute spinules. Maxillary palp a stout-based skewed peg; galea a tall frustum. Labial palp a low knob.

Bischoff (1927, p. 303) and Brun (1924, p. 57) referred briefly to the employment of larvae in producing the silk used in the construction of the nest.

Emery, 1925:— "En général, les *Polyrhachis* construisent leurs nids dans le feuillage des arbres, quelques espèces dans la terre ou dans les tronc morts. La soie filée par les larves est un élément essentiel dans leur confection, soit pour assembler les feuilles dont est composé le volumineux nid multiloculaire de *P. dives*,. . . . soit pour servir de trame à des nids petits et uniloculaires de nombreuses espèces, qui sont construits sur ou sous les feuilles. . . *P. simplex*. . . tapisse de soie une cavité souterraine" (p. 176). See also above under the subfamily.

Karawaiew, 1929, pp. 254–5:—"Der Grad der Entwicklung der Spinndrüsen bei den *Polyrhachis*-Arten gibt uns meines Erachtens in sämtlichen untersuchten Fällen einen tatsächlichen indirekten Beweis, dass es wirklich Weberameisen sind, hätten wir in den einzelnen Fällen auch nicht direkte Beobachtungen."

Wheeler, 1915:—The larvae of the subgenus *Cyrtomyrma* "though actively sericiparous in the construction of the nest, no longer spin a pupal envelope." (p. 331). In *Polyrhachis* "(excepting the species of *Cyrtomyrma*) more mature larvae are used as shuttles and the cocoon-spinning instincts have not been suppressed" (p. 333).

Subgenus **Chariomyrma** Forel

Polyrhachis (Chariomyrma) hookeri Lowne

Plate VI, figs. 12–18

Thorax and first abdominal somite forming a short stout neck, which is sharply marked off from the rest of the abdomen and which is strongly curved ventrally. Rest of the abdomen elongate-subellipsoidal; diameter greatest at the fifth and sixth abdominal somites, decreasing but slightly toward either end. Adjacent to the head the prothorax bears a ventral swelling. Lateral longitudinal welts feebly developed. Praesaepium well developed and apparently permanent; the posterior half of abdominal somite II is raised to form a transverse welt and, on either side, ridges extend forward from this welt to form the sides of the praesaepium. The floor of the praesaepium (and also the whole integument of abdominal somite X and the ventral surface of the thorax) densely spinulose, the spinules minute and in transverse rows. Anus subterminal with a conspicuous posterior lip. Leg vestiges present. Eight to 13 differentiated somites. Body densely and uniformly covered with short hairs, except on the ventral surface of the thorax and abdominal somites I and II where they become sparse. Hairs of three types: (1) 2 to 6-branched, about 0.08 mm long, the branches whip-like, without alveolus and articular membrane, the most abundant type;(2) denticulate, about 0.11 mm long, with alveolus and articular membrane; (3) a few simple hairs about 0.13 mm long, on the ventral surface of the thorax and abdominal somites I and II, with alveolus and articular membrane. Head subtrapezoidal in anterior view, narrowed above, maximum breadth about 1.4X the length; frons bulging. Head hairs numerous, moderately long (0.07-0.11 mm), of three types: (1) simple, (2) denticulate and (3) 2 to 4-branched; with alveolus and articular membrane; naked area conspicuous, in the form of an inverted V. Antennae small, each mounted on a drumlin-shaped convexity and bearing three (rarely four) sensilla. Labrum subparabolic in anterior view; anterior surface with eight short simple hairs and about four sensilla; ventral border with six projecting sensilla; posterior surface spinulose, the spinules minute and arranged in rows which radiate from the dorsolateral angles, the rows continuous near the base but broken distally; posterior surface with about 30 sensilla; chiloscleres present. Mandibles moderately sclerotized; subtriangular in anterior view; basal third broad and somewhat thick, distal two-thirds thin, blade-like and slightly curved anteriorly; apical tooth small, smooth, round-pointed and curved medially; lateral outline sinuous, not saddle-shaped; middle half of mesal border denticulate; anterior and posterior surfaces with a few longitudinal ridges, some of which are spinulose. Maxillae swollen ventrolaterally; apex in the form of a cone which is directed medially; all surfaces (except the lateral) roughened with short rows of minute spinules; palp a frustum, with four apical and one lateral sensilla; galea a tall frustum, with two apical sensilla. Labium with all surfaces sparsely spinulose, the spinules minute and in short transverse rows; palp a low knob bearing five sensilla; opening of sericteries wide and salient, with two projections. Hypopharynx densely spinulose, the

spinules arranged in subtransverse rows, the rows grouped in two subtriangles which have their bases near the middle. (Material studied: five larvae and six damaged integuments from New South Wales.)

Polyrhachis (Chariomyrma) jerdoni Forel

Forel (1923, p. 99 = 1928, Vol. II, p. 281) stated that the larvae were used in weaving the nest.

Subgenus **Campomyrma** Wheeler

Polyrhachis (Campomyrma) femorata F. Smith

Apparently similar to *hookeri* except in the following particulars:—Body hairs slightly longer. Anterior surface of labrum with about 14 hairs and six sensilla; posterior surface with about 25 sensilla. Apical tooth of mandible wider and blunter. (Material studied: eight damaged integuments from New South Wales.)

Subgenus **Myrma** Billberg

Polyrhachis (Myrma) gagates F. Smith

Plate VI, figs. 19–22

Apparently similar to *hookeri* except in the following details:—Body hairs of four types: (1) 5 to 12-branched, 0.11–0.15 mm long; (2) denticulate, 0.18–0.3 mm long, the most numerous type; (3) whip-like hairs, about 0.5 mm long, a few on the ventral surface of the thorax and abdominal somites I and II; (4) very long (about 1.0 mm) whip-like hairs on the dorsa of some somites. Entire integument spinulose, the spinules minute and in short transverse rows. Head hairs longer and all denticulate. Anterior surface of labrum with 14 hairs and ten sensilla. Apical tooth of mandible shorter, wider and blunter. (Material studied: four damaged integuments from the Congo.)

Polyrachis (Myrma) laboriosa F. Smith

Similar to *hookeri* except in the following details:—Body hairs of four types: (1) 12-branched, 0.05–0.1 mm long, the most abundant type; (2) denticulate hairs, 0.05–0.2 mm long, shortest in the middle of the body; (3) a few whip-like hairs on the ventral surface of the thorax and abdominal somites I and II, 0.11–0.35 mm long; (4) a few whip-like hairs on the dorsa of each of abdominal somites II-VI, about 0.9 mm long. Anterior surface of labrum with 12 hairs and ten sensilla. Apical tooth of mandible shorter, wider and blunter. (Material studied: two larvae from the Congo.)

Polyrhachis (Myrma) militaris cupreopubescens Forel

Apparently similar to *hookeri* except in the following details:—Body hairs of four types: (1) 5 to 12-branched. 0.075–0.15 mm long; (2) denticulate, 0.15–0.26 mm long; (3) whip-like hairs, about 0.23 mm long, a few on the ventral surface of the thorax and abdominal somites I and II; (4) whip-like hairs, about 1.0 mm long, a few each on the dorsal surface of abdominal somites II-VII. Head hairs all long (0.11–0.21 mm) and denticulate. Anterior surface of labrum

with 16 hairs and four sensilla; ventral border with four projecting sensilla. (Material studied: four damaged integuments from the Congo.)

Subgenus **Myrmatopa** Forel

Polyrhachis (Myrmatopa) sp.

Similar to *hookeri* except in the following details:—Body hairs sparser, of four types: (1) simple, 0.036–0.11 mm, fairly uniformly distributed except on the ventral surface of the thorax and abdominal somites I and II, without alveolus and articular membrane; the most abundant type; (2) simple, a few on each somite, about 0.09 mm long, with alveolus and articular membrane; (3) denticulate, about 0.054 mm long, a few on abdominal somites VIII-X, with alveolus and articular membrane; (4) one-hooked uncinate hairs, about 0.15 mm long, a few each on abdominal somites V-VII, with alveolus and articular membrane. Head hairs simple, fewer and shorter (0.035–0.09 mm). Labrum with ten hairs and ten sensilla on the anterior surface. Mandibles with a wider and blunter apical tooth. (Material studied: 12 larvae from the Philippine Islands).

Young larva:—Length 2 mm. The five anterior somites have nearly the same diameter; rest of abdomen slightly swollen. Anus ventral. Head wider than prothorax. Body hairs short, moderately numerous on the thorax and first two abdominal somites, sparse elsewhere. Hairs of three types: (1) short (0.009–0.054 mm) simple spikes, without alveolus and articular membrane, the most abundant type; (2) simple spikes, about 0.07 mm long, with alveolus and articular membrane, a few on each somite; (3) one-hooked uncinate hairs, about 0.11–0.14 mm long, with alveolus and articular membrane, a few each on the dorsa of abdominal somites III-IX. Integument of ventral surface of thorax and first two abdominal somites and the dorsal surface of abdominal somites VIII-X spinulose, the spinules minute and in short transverse rows. Labrum with the chiloscleres feebly developed. Opening of sericteries represented by two rounded knobs.

Polyrhachis (Myrmatopa) schang Forel

Karawaiew has figured (1929, Fig. 1 on p. 253) a profile enclosing the spinning glands of what he calls var. *parvicella;* the glands are described on page 252.

Subgenus **Myrmhopla** Forel

Polyrhachis (Myrmhopla) dives F. Smith

Similar to *hookeri* except as follows:—Body hairs of four types: (1) denticulate, 0.054–0.09 mm long, with rather long side branches, without alveolus and articular membrane, the most abundant type; (2) denticulate, 0.11–0.18 mm long, with alveolus and articular membrane, a few on each somite; (3) one-hooked uncinate hairs about 0.28 mm long, with alveolus and articular membrane, a few on the eighth abdominal somite; (4) simple hairs, 0.09–0.25 mm long, with alveolus and articular membrane, a few on the venter of the thorax and abdominal somites I-III. Head subrectangular in anterior view. Head hairs of

two types: (1) simple and (2) denticulate. Anterior surface of labrum with ten hairs and ten sensilla; ventral border with four projecting sensilla; posterior surface with about 16 sensilla. Apical tooth of mandible longer and wider. (Material studied: five integuments from China.)

Young larva:—Length 0.4 mm. Body hairs of three types: (1) 2 to 5-branched hairs, 0.018–0.054 mm long, most numerous on the thorax, fewer on the abdomen, none on abdominal somites VIII–X; (2) whip-like hairs, 0.036–0.18 mm long, most abundant and longest on the dorsa of abdominal somites II-VI; (3) one-hooked uncinate hairs, 0.09–0.18 mm long, on all somites, but most numerous on the thorax and abdominal somites V-X. Labrum with ten hairs and four sensilla on anterior surface. Mandible with apical tooth vestigial. Opening of sericteries represented by a pair of low swellings.

As in *Oecophylla*, the larvae of this species are used as shuttles to furnish the silk for weaving the nests and the shelters for Homoptera (*Nebennester*). This habit was first reported by Jacobson and Wasmann (1905) and was referred to again by Jacobson (1907, p. 36), by Emery (1925, p. 176) and by Forel (1923, p. 101 = 1928, Vol. II, p. 283).

Forel and Jacobson (1909):—The nest entrances were closed at night by silken webs spun by the larvae (p. 237). The larvae of *Oecophylla smargdina* were passive; the worker applied the larval mouth parts to the point where the thread was to be attached. When the worker of *dives* held a larva in its mandibles, the head of the latter was alternately protruded and retracted; consequently the worker held the larva near the point to which the thread was to be attached (p. 238).

Karawaiew (1929) (Fig. 8 on p. 255) a profile enclosing the spinning glands of what he called var. *rectispina;* the glands were discussed on page 254.

Wheeler, G. C. & E. H. 1924:—Two females of the eucharid *Schizaspidia polyrhachicida* G. C. & E. H. Wheeler were found in a cocoon of this ant from the Philippine Islands; presumably the eucharid larvae had been parasitic on the ant larva.

(**Polyrhachis** (**Myrmhopla**) **armata** (LeGuillou)

Karawaiew figured (1929, Fig. 2 on p. 253) a profile enclosing spinning glands; the glands were discussed on page 252.

Polyrhachis (**Myrmhopla**) **muelleri** Forel

Karawaiew, 1906:—"Von den jüngsten Larven dieser Ameise besass ich eine von 5½ mm Länge und eine andere von ungefähr 6½ mm. Erstere. . . gehört zu dem orthognathen Typus, ist sichelförmig gebogen und besitzt. . . 13 deutlich abgegrenzte Segmente . . . Wir sehen dass die Mundteile im allgemeinen sehr schwach ausgebildet sind; stärker ausgebildet sind nur die zahnartigen, dunkelbraun aussehenden Mandibeln. . . Die übrigen Mundteile glaube ich deuten zu müssen als Oberlippe. Maxillen, Seitenteile der Unterlippe mit je einem Paar stumpfer Warzen und Zunge. Die Haut der Larve ist mit kleinen Härchen dicht bedeckt, welche am Ende je 2–4 haarförmige Verzweigungen abgeben. Ausser diesen Härchen gibt es aber auf der Rückenseite noch spärlichere, unregelmässig zerstreute längere

und dickere etwas wellenartig verlaufende Hafthaare deren Ende wie ein Hammelhorn eingerollt ist" (p. 371). Fig. 4, larva in side view; Fig. 5, head in side view; Fig. 6, head in anterior view; Fig. 7, mandibles and labrum in anterior view; Fig. 8, body hairs. The salivary glands are described (p. 373) and figured (Fig. 10, repeated by Wheeler, 1910 as Fig. 124*A* on p. 222) and referred to by Karawaiew in 1929 (p. 253).

Polyrhachis (Myrmhopla) sexspinosa (Latreille)

Karawaiew figured (1929, Fig. 3 on p. 253) a profile enclosing spinning glands; the glands were described on page 253.

Polyrhachis (Myrmhopla) simplex Mayr

The larvae are used in nest-weaving just as in *Oecophylla*. A good account of this behavior was given by Lefroy and Howlett (1909, p. 232; copied by Dutt, 1912, p. 266). Hingston (1923, pp. 98–103) has written a long and interesting account of the use of larvae in the construction of byres; "the pointed head of the larva is made to project in front; it is very flexible and no doubt sensitive too, and it bends and turns to affix the thread wherever the worker may require" (p. 99).

Lefroy and Howlett, 1909, Fig. 129 on p. 226, a larva in side view; repeated by Lefroy, 1923, Fig. 178 on p. 525.

Polyrhachis (Myrmhopla) tibialis F. Smith

Karawaiew figured (1929, fig. 6 on p. 254) a profile enclosing spinning glands of what he calls var. *orientalis;* the glands are discussed on page 254.

Polyrhachis (Myrmhopla) wheeleri Mann

"When the first larvae are hatched, the mother uses their spinning abilities to line the nest with silk" (Mann, 1948, p. 306).

Subgenus **Myrmothrinax** Forel

Polyrhachis (Myrmothrinax) frauenfeldi Mayr

Karawaiew has figured (1929, Fig. 4 on p. 254) a profile containing the spinning glands; the glands are described on page 253.

Subgenus **Polyrhachis** F. Smith

Polyrhachis (Polyrhachis) lamellidens F. Smith

Yano, 1911:—"Larva long. Short hairs all over the body, growing in two rows on each somite. Hooked hairs about three times as long as the short hairs. Dorsal surface of thorax hairy. When young the larvae have very few hooked hairs. These are of use in hanging the larvae to the walls of the nest and also in attaching them in the cocoon" (p. 251, translated from the Japanese). Fig. 12, a larva in side view.

Subgenus?

Polyrhachis (subgenus?) *mystica* Karawaiew and *P.* (subgenus?) *tubifex* Karawaiew.—Karawaiew (1929) has figured profiles enclosing spinning glands (Figs. 7 and 5); the glands are described on pages 254 and 253.

DISCUSSION

The larvae of the Formicinae do not constitute a homogeneous group as do the larvae of certain other groups, for example, the Dorylinae, the Cerapachyinae, the Dolichoderinae and the Attini. This is perhaps to be expected since they are a much larger group. No character is distinctive, nor even any small group of characters. Our characterization of the subfamily includes numerous characters and many of these involve alternatives. Even then several exceptional genera are not covered.

With respect to degrees of specialization formicine larvae may be grouped thus:—

I. Melophorini—the most generalized; resembling closely the ponerine Ectatomma.

II. Plagiolepidini, Gesomyrmicini, Gigantiopini, Formicini—intermediate.

III. Camponotini—the most specialized as to elaboration of structure.

IV. Brachymyrmicini, Prenolepidini—transitional from II to V; the body shape is dolichoderine, but otherwise the anatomy is formicine.

V. Myrmelachistini, Oecophyllini—the most specialized by reduction; closely resembling the dolichoderines.

On the basis of larval characters, then, the following phylogenetic hypothesis might be justified. The Formicinae arose through the Melophorini from the ponerine Ectatommini. The main stem led through (or near) the Plagiolepidini, Gesomyrmicini, Gigantiopini and Formicini to the Camponotini. Side branches might lead through (or near) the Brachymyrmicini and Prenolepidini to the Myrmelachistini. The Oecophyllini should probably be placed on a spur all by themselves.

We have found it possible (but not always easy) to characterize the tribes, as is evidenced by our key. Of all the groups of ant larvae that we have studied the tribe Camponotini is perhaps the easiest to characterize, partly because it is homogeneous and partly because it has three unique characters which are easily seen: body shape, the chiloscleres and the praesaepium.

Genera likewise are easily defined and differentiated, except in the Camponotini. In this tribe the genera are so similar that we cannot differentiate them; hence they do not appear in our key.

Although we have studied large numbers of species in certain genera (*Formica*, *Lasius*, *Camponotus*) we do not deem it feasible to differentiate species. Before attempting such differentiation we would need more species and more material in each species. Then the study of only one large genus would require more time than we have devoted here to the entire subfamily. We might point out, however, that we have not found in the Formicinae any cases of congeneric species separated by characters of generic magnitude, such as we found in the Attini and Ponerinae.

SUMMARY

The larvae of 64 species in 18 genera are described and illustrated; all known references to formicine larvae in the literature are cited, bringing the total considered up to 117 species in 23 genera. A bibliography is appended. The larvae of the Formicinae do not constitute a homogeneous group and consequently are difficult to characterize as a subfamily. Tribes and genera (except in the Camponotini) are relatively easy to distinguish and define. In general, larval taxonomy parallels rather closely adult taxonomy. *Melophorus* is the most primitive genus and resembles rather closely the ponerine genus *Ectatomma*. The Camponotini are the most specialized, although *Myrmelachista* and *Oecophylla* are highly specialized by reduction.

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INSECT PHYSIOLOGY, By KENNETH D. ROEDER (Editor). Pp. xiv + 1100, 269 illus. John Wiley and Sons, Inc., New York. 1953. Price $15.00.

The first book published in this country on a continuously growing field, Roeder's "Insect Physiology" represents an herculean undertaking to collate past and recent information in the various areas of insect physiology, through monographic treatises by specialists actively engaged in research in each of these areas. The general plan of the book is the treatment of the physiology of the largest class of animals from the standpoint of organ physiology. With no major exceptions, chapters covering each field of insect physiology covered are critical, authoritative, lucid, and at the same time informative and interesting reading. The format of the book is excellent, the type is large and easy to read, and the illustrations, selected with obviously great discrimination, have been excellently reproduced. A bibliography of over 2500 references at the end of the book makes it an excellent starting place for study of the literature in each of the several fields of insect physiology. The inclusion of significant information on the mode of action of enzyme inhibitors, and on the toxicology and pharmacology of various chemical agents as regards the organ physiology of certain systems, especially insecticides, adds considerably to the utilitarian value of the book in bridging the narrowing gap between the more fundamental aspects of insect physiology and related areas of economic entomology and the chemical control of insects.

The editor is especially to be congratulated on the obviously excellent job of proofreading on so tremendous an undertaking and on his discernment in selecting so versatile a panel of experts in this country and abroad. The notable absence of the names of several contemporary contributors (Drs. Fraenkel, Williams, *et al.*) from the list of contributors may be a matter of personal desires on the part of the individuals concerned. There is an admitted omission of several subjects (*e.g.* insect bioluminescence, intermediary metabolism *per se*, and ecophysiology) and some overlapping, because of the classical organ physiology (as opposed to general or cellular physiological) approach. In this regard, while over 100 pages have been devoted to the borderline field of insect behavior, and over 85 pages to insect development (in introduction to the fields of experimental morphology, regeneration and endocrine control of development and molting), only 17 pages are devoted to the subject of excretion. (Obviously, effective exposition is appropriately credited to the individual contributors, whereas inadequacies are usually laid at the door of the editor who has generously permitted the contributors considerable freedom of expression and treatment.) It is anticipated that this first edition of what is to become a classical text and reference book will be appropriately altered, if not expanded, in future revisions. Since Roeder's "Insect Physiology" has been written with the assumption that the reader has had the usual general college training in zoology, chemistry, physiology entomology, required of students in the field of biology or zoology, it should become an essential part of the technical library of physiologists in general, both general and economic entomologists, and all students of the biological sciences. Without doubt it will be the established textbook in the evergrowing number of college and university courses in insect physiology.

M. ROCKSTEIN.

EFFECTS OF SMALL ENVIRONMENTAL CHANGES ON DEVELOPING SILKWORM EGGS[1]

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Nunome (1943) reported that a slight increase or decrease in atmospheric pressure during incubation of silkworm eggs increased survival ratio in the embryonal and larval stages. Yokoyama (unpublished) found that a slightly reduced pressure during the last day or two of embryonic life seemed to accelerate larval development. Cook (1945) claimed that less than 10% as many mealworms metamorphosed when kept in pure oxygen at 170 mm. total pressure as in air at 760 mm., but failed to give age, instar, mortality or feeding data. In an attempt to analyze further these effects, oxygen uptake and rate of development were measured in eggs after subjection to a 30 mm. Hg reduction in atmospheric pressure. The data are recorded at this time because there is no present possibility of extending the analysis.

Twenty batches of *Bombyx mori* eggs[2] of the "Choan X Taihei" strain, each containing about 500 embryos in the early "eyespot" stage (Umeya, 1937), were quartered and distributed to 40 otherwise empty Warburg flasks to form 20 pairs of samples, each experimental flask containing 250 eggs from the same females as its control flask. One flask of each pair was put into an air-filled vacuum chamber (net volume 5.6 L.) at 723 mm. Hg, the controls being left in a similar but unsealed chamber (barometric pressure nearly constant at 753 mm.; relative humidity averaging about 40%). At the end of 20 hours, 10 of the experimental flasks were removed and the chamber was re-evacuated to 723 mm. and left an additional 20 hours. Oxygen uptake at 25° C. of each set of 10 experimental batches, and of their 10 paired control samples, was measured every half hour over a 4-hour period immediately after the experimental eggs were restored to atmospheric pressure, and during corresponding periods on each of 2 successive days In addition to 10% KOH in the insets, the flasks contained 5.5% H_2SO_4 in the sidearms to absorb any NH_3 possibly evolved. The alkali and acid were in the flasks only during the actual respirometry, and except for those periods both experimental and control flasks were at the laboratory temperature of 21.7–24.4° C.

The mean rate of oxygen uptake over all but the first half hour of each 4-hour period was calculated for each experimental batch and

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[2]The individual weight of an egg including embryo, yolk and shell averages 0.4 mg.

for its paired control. For each pair the difference between mean experimental and mean control uptake was then obtained and the mean of the 10 such differences for each day and treatment was tested by t test against the hypothesis of no difference. An "over-all" test

TABLE I

MEAN O_2 UPTAKES (MM.^{3}/EGG/HOUR) OF SILKWORM EGGS AFTER EXPOSURE TO REDUCED OR NORMAL PRESSURE*

(p = probability of occurrence by chance; N.S. = difference not statistically significant)

Date	20 hr. at 723 mm.	Controls at 753 mm.	Mean Diff. between pairs of Experimentals and Controls, as Pairs	S. E. of Diff.	p
4/17	0.300 ± .010	0.296 ± .008	+.0037	.0050	> .40 N. S.
4/18	0.435 ± .018	0.424 ± .017	+.0111	.0049	< .05
4/19	0.471 ± .010	0.481 ± .011	−.0096	.0060	> .10 N. S.
Over-all			+.0052	.0014	> .70 N. S.
	40 hr. at 723 mm.	Controls at 753 mm.			
4/18	0.434 ± .024	0.395 ± .020	+.0391	.0094	< .01
4/19	0.550 ± .018	0.547 ± .018	+.0079	.0056	.20 N. S.
Over-all			+.0470	.0127	< .01

*In this and the following table it should be particularly noted that valid comparisons can only be made between experimentals and corresponding controls. The 20 hour experimental and control groups cannot be compared with the corresponding 40 hour groups because the respiration of the 20 hour groups had to be measured in the afternoons and that of the 40 hour groups in the mornings, and the 20 hour groups had one additional period of respirometry (i.e., four hours in a water vapor-saturated and CO_2-free atmosphere).

TABLE II

HATCHING RATIOS ON APRIL 19 OF EGGS INCUBATED UNDER REDUCED AND NORMAL PRESSURES*

Duration of Exposure of Experimental Batch to 723 mm.	Mean Hatching Ratio		Mean Difference between paired ratios	S. E. of Diff.	p
	Experimental	Control			
20 hr.	56.32%	50.33%	5.99%	± 1.19	< 0.001
40 hr.	62.70%	42.08%	20.62%	± 4.2	< 0.001

*Since the experimental eggs and their corresponding controls were killed and counted immediately after respirometry, the 20 hour-exposure eggs (afternoon run) were actually 4 hours older than the 40 hour-exposure eggs. This explains why the hatch was higher in the 20 hour controls than in the 40 hour controls, and indicates that the apparent difference in hatching ratio between the two experimental groups would have been even greater if referred to the same chronological age.

was also made for each treatment, using the net mean difference over the periods of measurement on the 2 or 3 successive days. The results are presented in Table I.

A measure of rate of development, expressed as percent of eggs which had hatched by the end of the experiment, is set forth in Table II. (Hatching was eventually 98–99% in independent control batches of the same strain of eggs.)

The results show (1) that the oxygen uptake of eggs exposed to reduced pressure for 20 hours was possibly significantly higher than that of their controls on the second day after exposure ($p = 0.05$); (2) that the oxygen uptake of eggs exposed to reduced pressure for 40 hours (2 consecutive 20-hour periods) was significantly higher than that of their controls on the first day after exposure, and on the first and second days combined ($p = < 0.01$); and (3) that eggs exposed to lowered pressure hatched significantly earlier than did their controls ($p = < 0.001$).

Though oxygen is not limiting to respiration in most insects until the pO_2 falls considerably below atmospheric, the oxygen available in the sealed vacuum chamber was of course 4% below that available to the controls in laboratory air, and may have been reduced as much as an additional 5% by the respiration of the eggs during the experiment. During the experiment, furthermore, water vapor and CO_2 concentrations in the air in the closed chamber presumably became slightly higher than in the air in which the controls in the unsealed chamber were living. Consequently, it is not certain that the effects on QO_2 and development rate were due solely to the 30 mm. reduction in atmospheric pressure. It will be apparent, however, that whatever the cause of the observed statistically significant effects, no environmental factor could have differed more than a few percent between the control and experimental batches of eggs. This emphasizes the necessity, in many types of experimental work on insects in laboratory air, for rigid control of often-neglected factors such as barometric pressure, humidity and gas concentrations.

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THE MOTH AND BUTTERFLY CLUB

According to James M. Unseld, Jr., Gravel Switch, Kentucky, the Moth and Butterfly Club is an organization open to anyone interested in the study of Lepidoptera. At present, there are fifty-five members. Annual dues are $1.50. The Club Notes are issued monthly in mimeographed form; Mr. Unseld is the editor. The April, 1953, issue is indicated as Vol. VIII, no. 4.

M. T. J.

NOTE ON MULTIMODAL CURVES

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In biological work one often comes up with data which are less homogeneous than one had hoped—in particular, with arrays that plot as multimodal curves. The ordinary text books of statistics used by biologists say nothing about such cases, and it seems that even a crude method of analysing them will be of use.

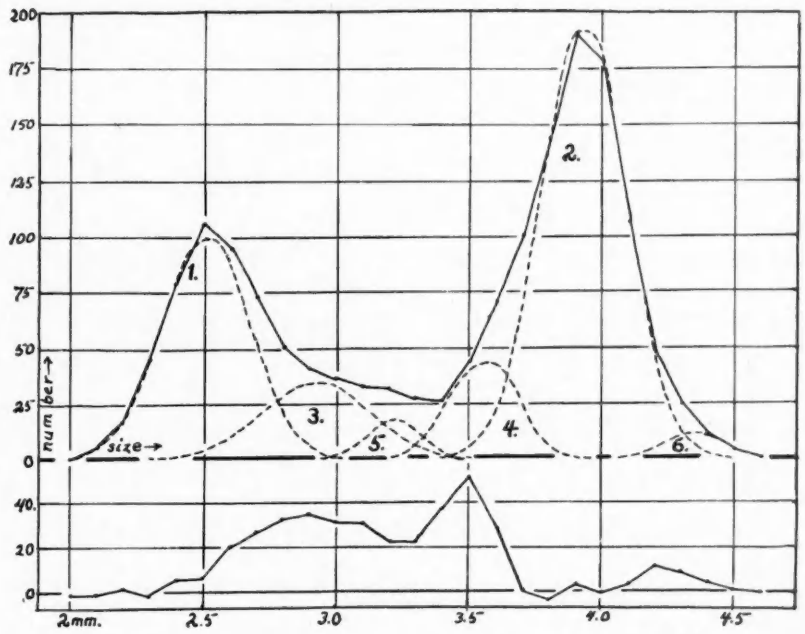

FIG. 1. Smoothed graph of head widths of *Myrmecia* workers (after C. P. & E. F. Haskins), and fitted components. Lower curve residuals after subtracting components 1 and 2.

I am taking as a specimen the data on heads of *Myrmecia*,[1] from a recent article in the ANNALS. In this case there are very obviously two modes, and the real problem is to determine whether the entire material represents random variation about these two modes, or if some more complex situation exists. There are other cases in which one has a more irregular curve, which is not so obviously bimodal.

[1]C. P. & E. F. Haskins. Ann. Ent. Soc. Amer., 43: 461–492, especially the graph on p. 477.

Some of these cases will yield to the same type of attack, if the data are not too ragged.

The basic idea is that a straight line is easier to recognize than any curve, therefore, that the data should be so transformed that a random distribution is represented by a straight line. If more than one mode is present the text-book methods will not work and the following is more powerful.

In the following development I am using the formula for the probability distribution in its simplest form, rather than the one given in statistical text books, since it is also better adapted for calculation with the slide rule. This form is $y = C \exp [-k(m-x)^2]$, which may

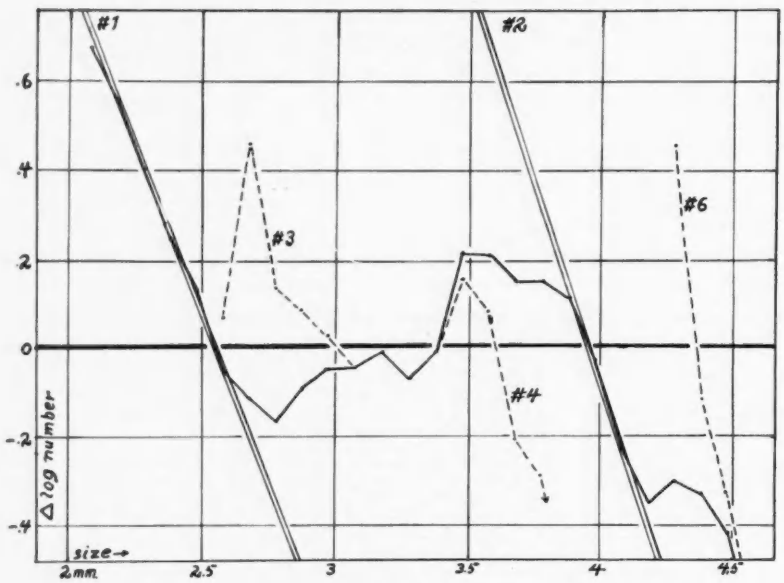

FIG. 2. Graph of differences of logarithms of numbers of each class (solid line), and fitted oblique lines, representing components 1 and 2 (double lines); also residue after subtracting components 1 and 2 (broken lines).

also be written: $\log y = -k(m-x)^2 \log e + \log C$. In this form C is the maximum height of the probability curve, m its mode (center), and k a quantity expressing the width of the curve. The standard deviation (σ) is related to k by the expression $k = \frac{1}{2\sigma^2}$.

For the first plot, take the differences of the logarithms of successive items of the data and plot at the mid-points of the intervals. Then any portion of the original data that represents a fairly pure random distribution about some mean, will approximate an oblique straight line; and if several modes are present, each will be represented by the

[2]On the log-log slide rule, to convert k and σ, set 2 on scale B against the end of scale A, and read k on scale A against σ on scale CI.

steep portion of an irregular line. If we then draw an actual straight line, as nearly as possible through each such series of points, these lines will represent the components (or part of them). The point of intersection of each line with the zero line (X-axis) is the value of the mode, and the width of the distribution is represented by the slope: $k = \frac{\text{slope}}{2n \log e}$, where n is the interval between points of observation.

In the present case (fig. 1, *l.c.*, graph) the data evidently have accidental irregularities, and a strong bias toward the even millimeters and half millimeters, so it is first necessary to smooth it somewhat.

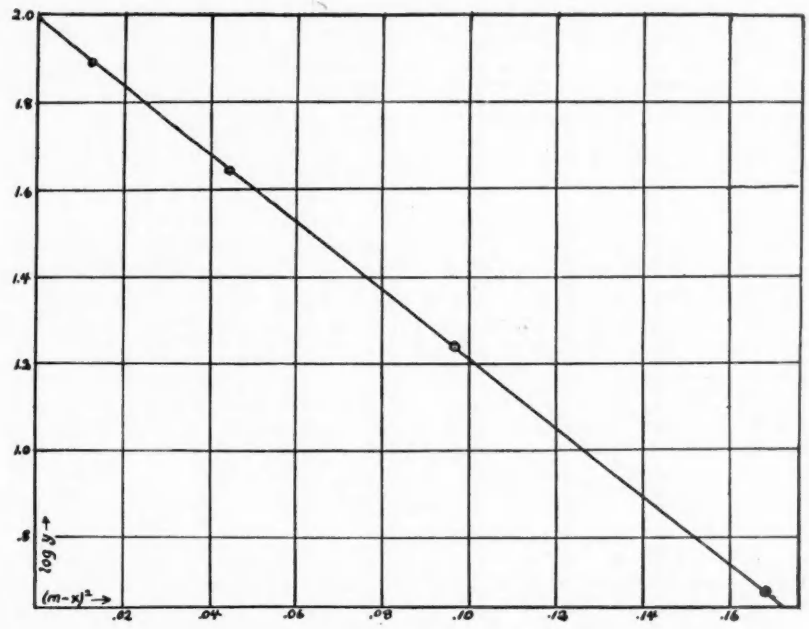

FIG. 3. Graph of log y against $(m\text{-}x)^2$, with fitted line for component 1.

I have reduced the millimeters and half millimeters by 30%, distributing this fraction between the points 0.1 mm. more and less. Then I have smoothed the whole as mildly as possible, by averaging each value with the average of the preceding and following ones $(a + 2b + c)/4$. This will have little effect on the result, but will make the curve smoother and operation easier.

This plot of the Δ log y values (fig. 2) shows two approximately straight sections, connected by an irregular portion, where the two components overlap, and where (as it turns out) there is at least one further component. There is actually a short downward slant in this portion, but it is much too slight to be rated significant. On drawing the two slanting straight lines (fig. 2), one can read immediately that

there are two large components, one with a mode within a few hundredths of a millimeter of 2.55 mm., and another at 3.9 mm. This plot, however, does not give the height of the two components (nor their area). The k value, and from it the standard deviation can be determined here, but the next step gives them with slightly greater precision.

For further development we need the other method of plotting the probability curve as a straight line. Consider the equation of the curve as given earlier: $\log y = -k(m-x)^2 \log e + \log C$. If we, then, plot $\log y$ against $(m-x)^2$, we again get an oblique straight line, in which the $\log y$ takes the place of y, and $(m-x)^2$ that of x in the familiar equation of the straight line, $y = ax + b$. The slope of the line (a) then is represented by $-k \log e$, or $k = -\frac{\text{slope}}{\log e}$, or numerically $2.3 \times$ slope.

In practice we plot only those points which produced the differences lying closest to the straight line in the first plot, and draw the best straight line through the series of points (fig. 3). The Y-intercept of this line is $\log C$, which is the third quantity we needed, and the value of k (and therefore σ) is both slightly more precise, and easier to calculate than that obtained from fig. 2.

The next step is to calculate the curves represented by m. k, and C, and subtract from the original curve.[3] I have done so and found the residuals plotted as the lower curve of fig. 2. It is obvious from the size of the residual mass that the population considered is not made up merely of random variation about two types, but involves a substantial number of intermediates. However, the curve is too irregular to give much hope of representing this intermediate population by calculated components, though its breadth suggests there are likely to be about two of these. Any confidence in further analysis would have to wait for study of additional nests.

Conclusion: A method is presented for the rough analysis of multimodal curves.

When applied to the population of a *Myrmecia* nest, it gives a statistical measure of the two large and obvious components, and shows that there are a substantial number of true intermediates.

Pushing the method to the limit, we come out with six components:

	m	k	σ	C	sum	
1	2.51 mm.	18	.167 mm.	100	415	well established
2	3.925	19.7	.159	195	775	well established
3	2.93	12	.204	35	180	parameters uncertain
4	3.56	32	.125	45	124	parameters uncertain
5	3.22	47.5	.103	18	46	existence uncertain
6	4.35	45	.105	12	30	existence uncertain

Total.....1571; actual total 1577

Probably the last decimal figure is insignificant in every case.

[3]This is easily done by the log-log slide rule. Set the end of the scale on the slide against the value of k on scale A; then each value of y (for $C = 1$) will be found on the LLO (or OO) scale opposite the value for m-x on scale C. Multiply by C as a separate operation.

NEW RECORDS OF MOSQUITOES FROM LOWER CALIFORNIA, MEXICO, WITH NOTES AND DESCRIPTIONS

(Diptera: Culicidae)

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HISTORICAL

Aitken (1942) reported the following species and subspecies of mosquitoes from the peninsula of Lower California:

(1) *Anopheles* (*Anopheles*) *maculipennis freeborni* Aitken (=*A. freeborni*)
(2) *A.* (*A.*) *pseudopunctipennis pseudopunctipennis* Theobald (=*A. pseudopunctipennis* var. *typicus* auct.)
(3) *A.* (*A.*) *pseudopunctipennis franciscanus* McCracken
(4) *Aedes* (*Ochlerotatus*) *taeniorhynchus* (Wiedemann)
(5) *Ae.* (*Finlaya*[2]) *atropalpus* (Coquillett)
(6) *Ae.* (*Kompia*[3]) *purpureipes* Aitken
(7) *Ae.* (*Stegomyia*) *aegypti* (Linnaeus)
(8) *Culex* (*Culex*) *tarsalis* Coquillett
(9) *C.* (*C.*) *stigmatosoma* Dyar (?)[4]
(10) *C.* (*C.*) *quinquefasciatus dipseticus* Dyar and Knab

Ross (1943) added the following three species to the list:

(11) *Aedes* (*Finlaya*) *varipalpus* (Coquillett)
(12) *Psorophora* (*Grabhamia*) *discolor* (Coquillett)
(13) *P.* (*G.*) *signipennis* (Coquillett)

Downs and Bordas (1949), in a survey of malaria of the Southern Territory, collected specimens of a fourteenth species, *Deinocerites epitedeus* Knab, in crab holes at San Jose del Cabo.

HABITAT DESCRIPTIONS AND SPECIES COLLECTED

During two brief trips along the coastal highway of Lower California, between Tijuana and Ensenada, on June 13 and June 25, 1948, respectively, we obtained a number of mosquito species not previously recorded from Lower California. The purpose of this article is to report the new records; to describe in detail the previously unknown larva of *Culex* (*Melanoconion*) *anips* Dyar and all stages of *Culex* (*Neoculex*) *reevesi* Wirth, none of which have been adequately described; and to illustrate the male terminalia of *Uranotaenia anhydor* Dyar, described too poorly in the past to allow certain identification.

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[1]Scientist, Communicable Disease Center, Public Health Service, Federal Security Agency, Atlanta, Georgia.

[2]Vargas (1949a) holds the opinion that *Finlaya* Theobald, 1903, is an Oriental subgenus and has resurrected the subgeneric name, *Gualteria* Lutz, 1904, to include those American species formerly grouped under *Finlaya*.

[3]Vargas (1949b) has synonymized this subgenus with *Ochlerotatus* on the basis of the morphology of males and larvae collected from a tree-hole in San Blas, Sinaloa, Mexico.

[4]Question mark is Aitken's.

Collections were made at two localities. The first of these was 46 kilometers south of Tijuana. At this point a small stream flowing into the ocean had been ponded by a sandbar across the ocean outlet; as far as could be determined, the water in this pond was not saline. The impoundment, at the time of our visit, was approximately 15 feet wide and 100 feet long with a maximum depth of about five feet. A thick growth of tules fringed the pond, and the surface of the shallower water was covered with algae and duckweed (*Lemna*). Larva were collected at the edge of the tule patch as well as in the mat of algae and *Lemna*. The following species of mosquitoes were collected in this pond:

(1) *Anopheles* (*Anopheles*) *freeborni* Aitken
(2) *A.* (*A.*) *pseudopunctipennis franciscanus* McCracken
(3) *Culex* (*Culex*) *erythrothorax* Dyar
(4) *C.* (*C.*) *thriambus* Dyar
(5) *C.* (*Neoculex*) *reevesi* Wirth
(6) *C.* (*Melanoconion*) *anips* Dyar
(7) *Uranotaenia anhydor* Dyar

All of the above species with the exception of the *Anopheles* are reported for the first time from Lower California.

The second collection site was at "La Salina" (Cafe La Misión), approximately 65 kilometers south of Tijuana. At this point larvae of *Culex* (*Culex*) *tarsalis* Coquillett were collected in large numbers in a brackish tidal marsh, and adults of *Aedes* (*Ochlerotatus*) *squamiger* (Coquillett), a new record for Lower California, were collected under the highway bridge. The larvae of *C. tarsalis* exhibited the short, globular anal gills so typical of salt-marsh inhabiting mosquitoes.

We have recently received additional records of Lower California mosquitoes from R. M. Bohart, who collected along the stream at the 46 kilometer post south of Tijuana on April 25, 1950, and who has kindly permitted us to include these records in this paper.

Larvae of the following species were collected by Dr. Bohart:

(1) *Anopheles* (*Anopheles*) *pseudopunctipennis franciscanus* McCracken
(2) *Anopheles* (*A.*) *occidentalis* Dyar and Knab[5]
(3) *Culex* (*Culex*) *erythrothorax* Dyar
(4) *Culex* (*C.*) *tarsalis* Coquillett
(5) *Culex* (*C.*) *restuans* Theobald[6]
(6) *Culex* (*C.*) *thriambus* Dyar
(7) *Culex* (*Neoculex*) *reevesi* Wirth
(8) *Culiseta* (*Culiseta*) *maccrackenae* Dyar and Knab[6]

He also reports capturing adults of *Aedes* (*Ochlerotatus*) *taeniorhynchus* (Wiedemann) in the act of biting.

DESCRIPTIONS AND NOTES OF SPECIES

Culex (**Neoculex**) **reevesi** Wirth

This species originally was described in manuscript by Galindo (1943) from specimens collected at Hotel del Monte, Monterey, Cali-

[5] *Anopheles maculipennis* Meigen was reported from Tijuana by Dyar (1907). This may have been *A. occidentalis* or, as Aitken (1942) suggests, Dyar's specimens were *A. freeborni* Aitken.

[6] New record for Lower California.

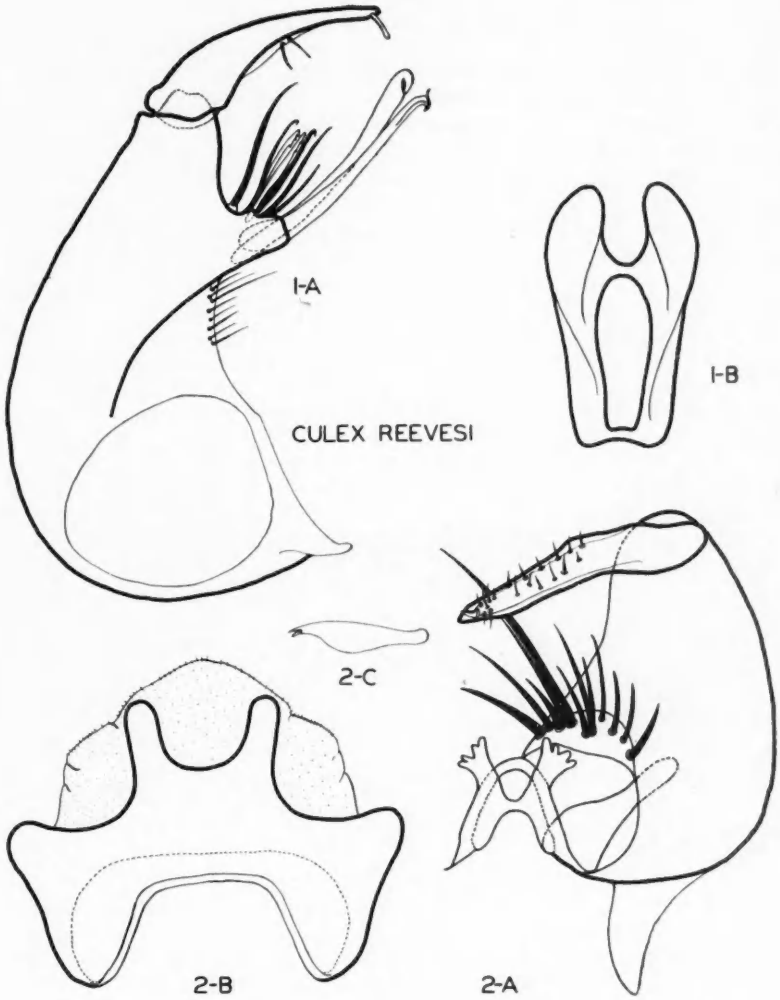


FIG. 1. *Culex* (*Neoculex*) *reevesi* Wirth, male terminalia. a. Sidepiece. b. Phallosome armature. (Drawn from Camera Lucida.) FIG. 2. *Uranotaenia anhydor* Dyar. a. Sidepiece. b. Ninth tergite and anal lobe (anal lobe collapsed on specimen; outline drawing represents an hypothetical reconstruction). c. Lateral view of dististyle of sidepiece (our specimen oriented as in figure 2a; Dr. Alan Stone prepared freehand sketch of lateral view from an additional specimen, and we have copied Dr. Stone's sketch). (Drawn from Camera Lucida.)

fornia. The first use of the name, *Culex reevesi*, in publication, was by Wirth (1948), who included characters sufficient to separate it from other species in keys to the females and larvae of mosquitoes of California. *Culex reevesi* Bohart 1948 is not this species and has been renamed *C. boharti* by the present authors (for a clarification of the systematics of *C. reevesi* and *C. boharti*, see Brookman and Reeves, 1950). Since a complete description of this species has not as yet been presented in published form, it seems appropriate to do so at this time. The following descriptions are based on a series of 10 females, 6 males (from 4 of which terminalia were removed and mounted for study), 10 larvae, and 3 pupal skins.

Female.—Proboscis and palpi dark scaled. Palpi 2.5 times as long as fourth flagellar segment of antennae as seen in lateral view. Narrow line of whitish scales above eyes on vertex, broadening laterally; other appressed scales on vertex yellowish brown, upright forked scales dark brown; integument of mesonotum light brown, bearing yellowish scales and black bristles; two submedian longitudinal bare stripes extending from anterior margin of scutum to antescutellar space. Postscutellum light brown with central narrow dark stripe. Wings dark scaled. Halteres light brown; knobs darkened, with few whitish scales. Tergites of abdominal segments black scaled; apical abdominal bands lacking on segments I to IV; scattered grayish scales along apical margins of segments V, VI and VII; apicolateral triangular spots of grayish scales on all segments; venter covered with grayish scales; fifth abdominal segment of dry, unengorged specimens longer than broad. Femora with broad pale band beneath on all but extreme apex, as seen from lateral view; tibiae and tarsi dark scaled.

Male.—Terminal palpal segment with moderate to long hairs along entire length as viewed from above; "long" segment with three or four erect hairs at apex; palpus about 1.25 times as long as proboscis. Coloration of body as in female. Tergites of abdominal segments V and VI, as long as or slightly longer than broad. *Terminalia*: ninth tergite of small discrete lobes connected by narrow bridge, each lobe bearing five to nine stout bristles. Side-pieces as in fig. 1-A. Subapical lobe of basistyle an elongate, triangular fold on dorsal (primitive sense) surface; this lobe bears at apex two stout, deeply embedded rods which are recurved at tips, four blade-like processes, two of which appear to be serrate along one edge, and several simple setae; stout rods are about one-third longer than blade-like processes. Dististyle acutely tapered to tip, bearing blunt subapical digit and two short setae close together near middle of structure; paraprocts of tenth segment with clump of stout spines at tip; three or four small setae on membranous area between apex of tenth tergites and paraprocts. Lateral plates of phallosome (fig. 1-B) somewhat roughened apically but without definite tubercles or spines as in other described North American species of *Neoculex;* plates connected by sclerotized bridge at outer third and at base.

Fourth Instar Larva.—Head broader than long. Antenna constricted at apical third, tuft of multiple hairs inserted at constriction; light brown pigmentation at base of shaft and on outer third; prominent slender spines on basal two thirds of shaft, few stout thorn-like spines

on apical third; apical armature consists of two subterminal bristles and one terminal bristle, all equal in length and two-thirds length of antennal shaft, a short terminal spine about one-fifth length of long bristles, and papilla which is pigmented on basal two thirds and hyaline on outer third. Upper head hairs with three branches, about three-fourths length of lower which have two branches. Ante-antennal tuft multiple, with five to seven branches. Mentum variable, with 11 to 16 teeth. Thorax moderately spiculate. Prothoracic shoulder hairs numbers 1, 2, 5, and 6 single, stout, about twice length of head; number 3 two-branched, each branch about one-half thickness and one-half length of hair 1; number 4 two-branched, each branch slightly less

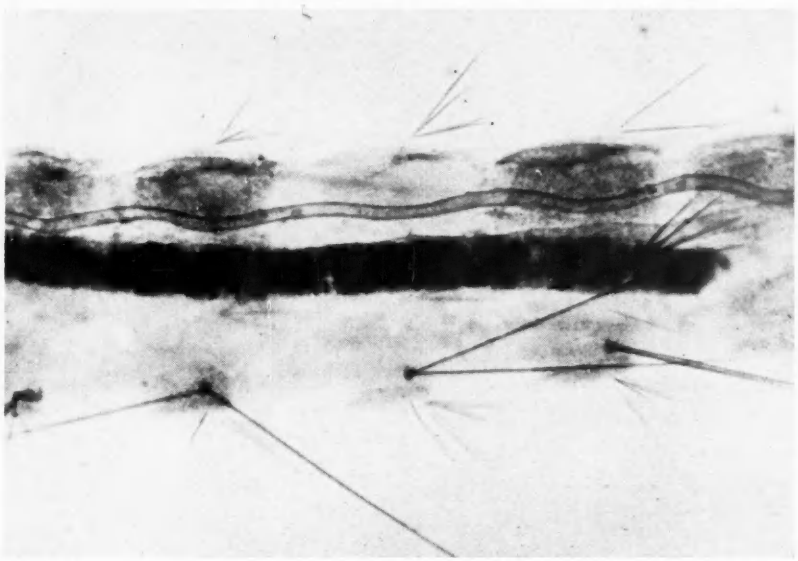


FIG. 3. *Culex reevesi*. Fourth instar larva, illustrating lighter pigmentation of fourth abdominal segment.

stout and three-fourths length of hair 1; number 7 three-branched, each branch approximately equal in thickness and length to that of hair 4. Mesothoracic hair number 1 with three branches, about one-third length of antenna. Abdomen with segment IV less heavily pigmented than that of other segments (fig. 3). Comb of segment VIII with 39 to 71 scales (average of nine observations, 58) in triangular patch, each scale fringed along entire length and apically. Siphon (fig. 4) from 5.3 to 6.4 times as long as basal width (average of 9 larvae, 5.6:1); five pairs of tufts, basal tuft from 1.6 to 1.8 times as long as basal diameter of siphon (average of 9 larvae, 1.7:1); 13 to 19 pecten teeth (average of 18 observations, 16), apical tooth before, equal to or beyond basal hair tuft. Anal segment about twice as long as broad; sclerotized plate encircles segment and bears spinules which are heaviest on dorsoapical portion; lateral hair single or double.

Pupa.—Only three complete mounted female exuviae are at hand. Careful examination has not revealed any essential differences between the pupae of this species and those of *C. bohartí*, with which it is most closely related (see description of *C. reevesi* Bohart in Bohart, 1948). In closely related species such as these, statistical analyses of setal lengths as well as the number of branches of certain key setae may reveal significant morphological differences. However, until additional specimens of *C. reevesi* are available, this cannot be done.

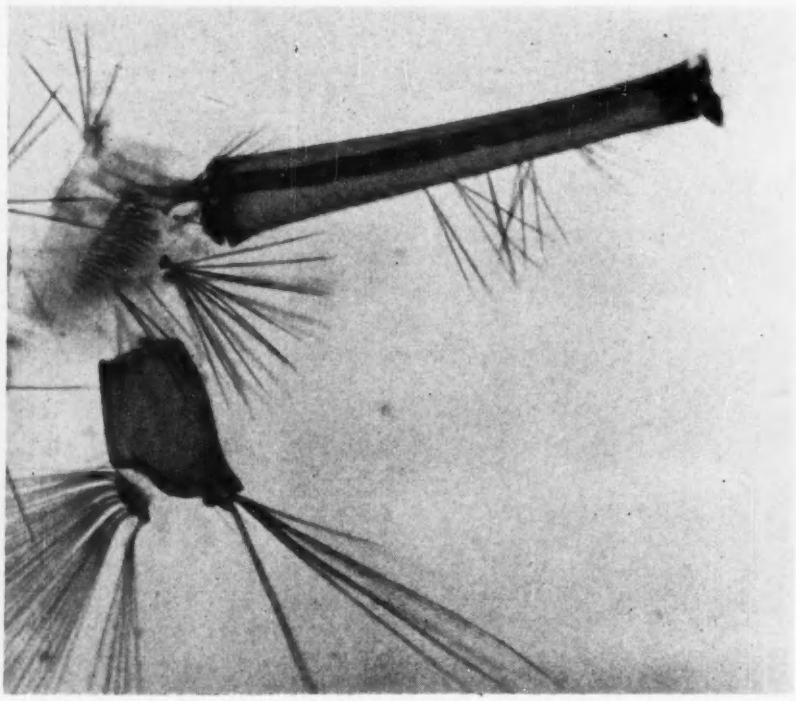


FIG. 4. *Culex reevesi.* Fourth instar larva. Terminal abdominal segments and siphon.

Type.—Galindo (*loc. cit.*) designated a "male, terminalia dissected and mounted in balsam on a slide" as "holotype". Although we have not seen this "type," which apparently is in Galindo's collection, his description and drawings of the male terminalia agree perfectly with our specimens from Lower California.

Distribution.—We have seen specimens only from Lower California. Galindo (*loc. cit.*) gave the following additional locations: Hotel del Monte, Monterey, California; Pt. Reyes Station, Marin County, California; and San Luis Obispo County, California. He also indicated that he believed the specimen from San Diego, California referred to by Dyar (1916) as "*Culex* species" might be *C. reevesi.* It is entirely possible that the females from Pt. Reyes and San Luis Obispo may be

C. boharti Brookman and Reeves, as we have examined specimens from the middle coastal region of California which appear to be that species.

Discussion.—Adults of *C. reevesi* Wirth may be distinguished from all other Nearctic species of *Neoculex* except *Culex derivator* Dyar and Knab, some specimens of *Culex territans* Walker, and *Culex boharti* Brookman and Reeves (see Bohart, 1948) by the absence of distinct apical bands on the abdominal tergites. Females differ from those of *derivator*, *apicalis* Adams, and *arizonensis* Bohart in having relatively short palpi, and from those of *territans* and *boharti* in having the fifth abdominal segment longer than broad. The male terminalia of *C. reevesi* differ from those of all other North American species of *Neoculex* in the absence of spines or tubercles on the tips of the phallosome plates. The larva may be distinguished from that of its closest relative, *C. boharti*, by the presence of three-branched upper head hairs and two-branched lower head hairs.

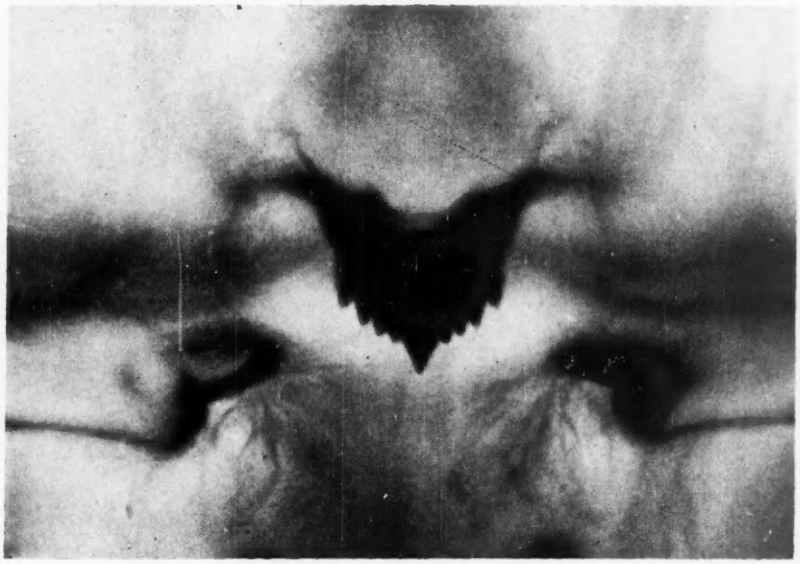


FIG. 5. *Culex anips*. Fourth instar larva. Mentum.

Culex (Melanoconion) anips Dyar

This species was described by Dyar from one male and one female reared from pupae collected at San Diego, California, in a large pool at the mouth of the San Diego River. This pool, according to Dyar (1916) was "about 50 by 300 feet in size, the water deep, the cattails growing in a fringe along the shore at a depth of about three feet. Masses of *Lemna* were lodged in the reeds, though the main part of the pond was open. Fish were present. . . . Red-winged blackbirds frequented the reeds, which hold many of their nests with eggs and young." The

habitat from which *C. anips* was taken in Lower California is, in general, quite similar (see above).

Until the time of our collections, the larva of this species was unknown. For this reason, the fourth-instar larva is described below. The identity of our specimens was confirmed by W. H. W. Komp of the Public Health Service and by Alan Stone of the U. S. National Museum, on the basis of male terminalia.

Fourth-Instar Larva.—Head about one and one-half times as broad as long. Antenna approximately equal in length to head, constricted at outer third; clear area before constriction bearing fine spinules; pigmented area beyond constriction with few stout thorns; antennal

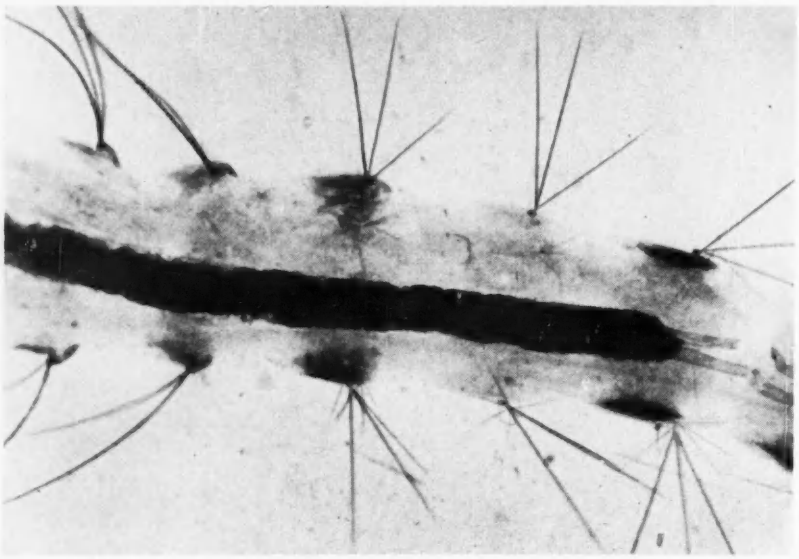
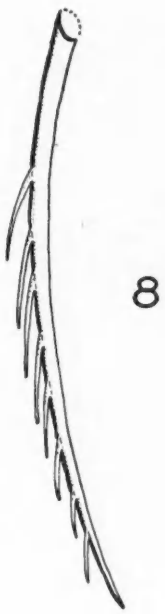


FIG. 6. *Culex anips*. Fourth instar larva, illustrating unpigmented condition of fourth abdominal segment.

tuft inserted at point of constriction, multiple, individual hairs pinnate; two bristles subterminal and one terminal, two-thirds length of antenna; short terminal spine sharply pointed, over one-half length of constricted portion; papilla inconspicuous, stout, about one-fourth length of short terminal spine. Preclypeal spines stout, darkly pigmented, acute at tip, about one-fifth length of head. Antenantennal tuft multiple, individual hairs pinnate. Postclypeal hairs single, slender, about one-half length of upper head hairs. Lower head hairs single, strong, approximately equal to length of head; upper head hairs single or double, rarely triple (more frequently double), weak, approximately one-half length of lower head hairs. Mentum with strong central tooth, four lateral teeth on either side of center which are weaker toward center, stronger laterally, and an additional tooth on either side toward base of structure (fig. 5). Thorax with integument bearing many fine

spicules. Prothorax with hairs 1 and 2 single, strong, two and one-half times length of head; hair 3 six-branched, weak, one-third length of head; hairs 4 and 5 single, strong, as long as hair 1; hair 6 three to four-branched, strong, equal to head in length; hair 7 two-branched, strong, one-third longer than head; hair 0 weak, one-third length of hair 3, six-branched. Mesothorax with submedian hair (#1) weak, four- to seven-branched, about equal in length to prothoracic hair 3. *Abdomen* with integument bearing fine spicules. Fourth segment unpigmented (fig. 6). Comb of 40 or more scales in a triangular patch. Individual scale illustrated in fig. 7. Siphon (fig. 9) from five to seven times as long as basal width; moderately tapered to apex; five pairs of



Culex (*Melanoconion*) *anips* Dyar. FIG. 7. Individual comb scale. FIG. 8. Terminal pecten tooth.

ventrolateral hair tufts, basal one about three times as long as width of siphon at insertion, subsequent ones decreasing in length to fifth pair which is about one and one-half times as long as width of siphon at insertion; two pairs of short subdorsal tufts; terminal pecten tooth illustrated in fig. 8. Anal segment twice as long as wide; saddle ringing segment, densely spiculate on dorsal part; lateral hair two- or three-branched, weak, very short; gills about one-third length of segment.

The larva of *C. anips* runs to *Culex elevator* Dyar and Knab in the key to *Melanoconion* of the United States (Wirth, 1945). The former may be distinguished from the latter as follows: preclypeal spines of *anips* about one-fifth length of head, those of *elevator* closer to one-

tenth length of head; mentum of ***anips*** with four closely-placed teeth on either side of central tooth and one additional tooth on either side basally, that of ***elevator*** with five teeth closely placed on either side of central tooth as well as the additional basal tooth; fourth abdominal segment of ***anips*** unpigmented, that of ***elevator*** pigmented; pecten of ***anips*** slender, with fine lateral teeth, those of ***elevator*** shorter, stouter, with coarser lateral teeth. (We are indebted to W. W. Wirth of the United States National Museum for the loan of specimens of *C. **elevator*** to compare with *C. **anips***.)

Specimens have been deposited in the collections of the U. S. National Museum, the California Academy of Sciences, and the Communicable Disease Center, Atlanta, Georgia.

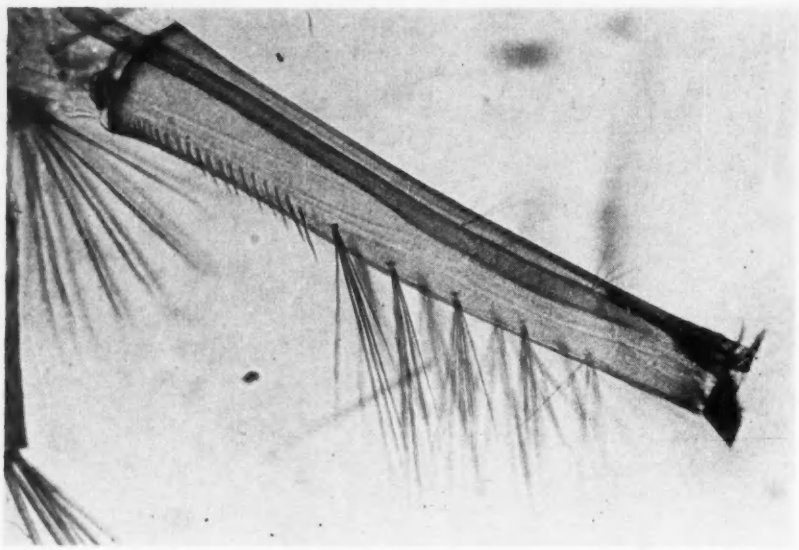


FIG. 9. *Culex **anips***. Fourth instar larva. Siphon.

Uranotaenia anhydor Dyar

Dyar (1907) reported having first collected a single larva of this species at Sweetwater Junction, near San Diego, California in 1906 and based the original description on this specimen. Additional specimens were obtained by Dyar in the spring of 1916 in association with *C. **erythrothorax***, *C. "**territans**"* (possibly ***reevesi***), *C. **anips***, *A. **pseudopunctipennis*** (probably subspecies ***franciscanus***) and *A. **occidentalis***. Freeborn (1926) collected a single female in an artificial shelter at Camp Kearney, near San Diego, in May, 1918. Seaman (1945) reported the collection of one larva from a "grass-tule marsh in the river bed of the San Luis Rey River," near Bonsall, San Diego County, California.

In the collections reported upon herein, two pupae of *U. **anhydor*** were taken by the present authors. These were reared, and one female and one male emerged. A review of the literature revealed that no

adequate description of the male terminalia of this species was available. Therefore, a line drawing was prepared to illustrate the salient characters (figs. 2A, B, C). This was compared with one of Dyar's specimens kindly furnished us by Dr. Alan Stone of the United States National Museum and found to be identical.

Dr. Harry Pratt of the Communicable Disease Center has called our attention to the fact that the morphology of *U. anhydor* terminalia as illustrated by us appears to be quite similar to that of *Uranotaenia syntheta* Dyar and Shannon from Texas and to agree closely with the description and figures prepared from Mexican specimens of *syntheta* by Dampf (1943). After examination of one male *U. syntheta*, collected in San Antonio, Texas and identified by E. S. Ross of the California Academy of Sciences and of Dampf's drawings, we agree that the terminalia of the two species are much alike. It should be noted, also, that Breland (1950) considers the larva of the two species to be "very similar." With the small amount of material at hand it is possible at present only to suggest that there may be a closer relationship between *U. anhydor* and *U. syntheta* than has previously been suspected and that we may be dealing with two subspecies or even with a single species. The possibility that there may be a link between the western *anhydor* and the Texas-Mexican *syntheta* is borne out to some extent by a recent collection in western Nevada of what appears to be *U. anhydor* by Dr. C. B. Philip of the Rocky Mountain Laboratory. Unfortunately, only females were taken. Further collecting of mosquitoes in the Southwest may reveal that *Uranotaenia* is more widely distributed throughout the arid regions than is believed at present.

SUMMARY

Previous records of mosquitoes occurring in Lower California, Mexico, are reviewed. The following eight species are reported for the first time from that region: *Aedes squamiger*, *Culex erythrothorax*, *C. thriambus*, *C. restuans*, *C. reevesi*, *C. anips*, *Culiseta maccrackenae*, and *Uranotaenia anhydor*. Descriptions of the adult and larva of *C. reevesi* and the larva of *C. anips*, and illustrations of the male terminalia of *U. anhydor* are presented.

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CYTOCHEMISTRY: A CRITICAL APPROACH, by J. F. Danielli. Pp. 139, 12 plates, 8 text figures. J. Wiley & Sons, Inc., New York, 1953. Price $4.00.

During the spring of 1949 J. F. Danielli, Professor of Zoology, King's College, presented a series of lectures in the Department of Zoology at the University of Chicago. The present volume is a slightly enlarged version of these lectures. A listing of the titles of the seven chapters will serve to indicate the contents of the volume: Introduction; Fixation Procedures; Studies on Alkaline Phosphatase; The Critical Study of the Cytochemistry of Aldehydes; The Cytochemistry of Proteins and Nucleic Acids; Quantitative Studies in Cytochemistry; The Future Outlook in Cytochemistry. Although objective approaches for determining the usefulness of chemical fixatives are presented, the author stresses the inadequacy of most of the orthodox histological and cytological techniques for purposes of cytochemistry. He somewhat overstates his case for the virtues of the freeze-dry method, however, in comparing results obtained with a special-purpose chemical fixative such as Carnoy's. The author's recommendation is for the use of freeze-drying wherever possible. Where not possible he concludes that chemical fixation will give a picture "correct in outline, but misleading in detail." The chapter on alkaline phosphatase, the longest (50 pp.) in the volume, is devoted to the detailed applications of cytochemistry to the study of the presence and possible significance of alkaline phosphatase in cellular metabolism. The Feulgen reaction with aldehydes hydrolyzed from deoxyribonucleic acid is considered in Chapter 4, and is followed in Chapter 5 by a consideration of Caspersson's ultraviolet absorption spectra studies bearing upon the identification and localization of nucleic acid and proteins in the cell. Two possible functions of nucleic acids in protein synthesis are suggested: (1) that they are folding agents, which set the pattern of the polypeptide chain, and (2) that they are trapping agents, which combine with protein to allow the equilibrium between a protein and its precursors to shift in the direction toward further synthesis of the protein. Chapter 6 considers the sources of errors to which quantitative cytochemistry is subject. In conclusion the author discusses several advantages of the cytochemical as opposed to the biochemical approach. The 12 plates of photomicrographs are excellently reproduced, and are well-chosen to illustrate the potentialities of cytochemical methods. Although there are references to work with *Drosophila*, *Habrobracon*, and to insects in general, the volume stresses no particular group of organisms.

Adolph Hecht.

A SUGGESTED CLASSIFICATION OF THE LOWER BRACHYCEROUS DIPTERA

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The most primitive Brachycera, those in which the empodium is pulvilliform and in which specialization and reduction of the antennal flagellum and the wing venation have progressed least, are in a confused state in regard to the taxonomy of their higher categories. The group as a whole was set apart as the Homoeodactyla by Brauer (1883) and in more recent systems (Coquillett, 1901; Tillyard, 1926; Hardy, 1944) has come to be considered a single superfamily called the Tabanoidea. Within the group, however, erection of families and subfamilies has been excessive and placement of many genera has been far from settled.

Detailed knowledge of the immature stages is largely lacking. The larvae especially are of diverse form and exhibit great adaption to habitat and food. Much more information will have to be available before we can discern which characters are phylogenetically significant and which are adaptive. The characters of the immature stages have for these reasons been largely disregarded in the present study.

The chief features of the classification here proposed are: a) the acceptance of the consolidation of the flagellum as a primary character, setting the Rhagionidae, Nemestrinidae[1], and Acroceridae sharply apart from the remainder; b) the use of the divergence of wing veins R_4 and R_5[2] as the prime character in dividing the group with incompletely consolidated flagellum; and c) stress on the position of the radial sector (Rs, praefurca) as an important character.

The divergence of veins R_4 and R_5 takes on significance when the studies of Vignon and Séguy (1929, 1929a) and Hardy (1927, 1946, 1946a, 1947, 1949) are considered. It appears possible that the "R_5" of the widely divergent forms may actually be a part of the medial field. At any rate, without considering venational homologies, it would appear that the character is one of phylogenetic consequence and one that neatly brings together related forms.

The chief effect of the use of the above characters is to further restrict the old Rhagionidae and to enlarge the Coenomyiidae and Erinnidae.

It is hoped that further studies, such as upon the immature stages and the genitalia, will corroborate the conclusions here reached.

The proposed scheme may be shown in a tabular key, as follows.

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[1]Except the genus *Exeretoneura*, *q.v.*, *infra*.

[2]Considering the radial sector traditionally as doubly biramose.

FAMILIES OF TABANOIDEA

A. Third antennal division (flagellum) compact, unsegmented, with a slender apical or subapical style or arista which has but a single basal segment (except in the Nemestrinid genus *Exeretoneura*, of Australia, in which the flagellum is thickened and annulate, and some other Nemestrinidae which have an aristate flagellum with two segments at the base of the arista); costa of wing circumambient or squamae enlarged (or both in some Acroceridae); wing venation often highly specialized.

B. Wing veins normal; costa circumambient; squamae reduced; at least posterior tibiae with spurs; proboscis greatly lengthened only in *Lampromyia* ..... **Rhagionidae**

BB. Venation usually specialized and costa usually reduced posterior to wing tip; tibiae with short or no spurs; proboscis sometimes greatly lengthened.

C. Wings sometimes with archedictyon apically; at least one branch of M extending to wing tip; usually with posterior veins parallel to margin of wing; squamae reduced; head as wide as the depressed thorax ..... **Nemestrinidae**

CC. Wings never with more than a few supernumerary crossveins; never with any branch of M extending to wing tip; venation frequently greatly reduced; squamae enlarged; head very small as compared to the humped thorax ..... **Acroceridae**

AA. Flagellum distinctly annulate or articulate, usually thick (if with slender arista, as in some Stratiomyidae, the basal portion is annulate); costa circumambient or not, circumambient if squamae are enlarged (Tabanidae); wing venation relatively generalized, at most with veins crowded anterad, discal cell small, and some branches of R and M atrophied; R_5 sometimes ending anterior to wing tip; wing never with supernumerary crossveins or fusions.

B. Wing veins R_4 and R_5 divergent, R_5 ending well behind tip of wing; costa circumambient; eyes of male usually holoptic; at least middle tibiae with spurs, although rudimentary in Pantophthalmidae.

C. Squmae enlarged; R_s originating well basad of base of discal cell; occiput flat or concave, closely applied to thorax .. **Tabanidae**

CC. Squamae small or lacking.

D. Radial sector originating opposite or but slightly before base of discal cell; cell M_3 closed before wing margin; only middle tibiae with spur (single rudimentary one); face often produced beak-like below; very large flies of the American tropics ..... **Pantophthalmidae**

DD. Radial sector originating well before base of discal cell; cell M_3 not or but slightly narrowed toward wing margin; hind tibiae with spurs; face not produced below; hind femora not toothed ..... **Coenomyiidae**

BB. Wing veins R_4 and R_5 divergent or not, but R_5 never ending much behind wing tip; costa circumambient only in *Erinna*.

C. Radial sector originating at or close to base of discal cell; tibiae without spurs (except in *Allognosta* and probably other Beridinae); scutellum often armed; males usually holoptic; hind coxae without anterior tubercle; abdomen with five or six unreduced segments, except in Beridinae and Chiromyzinae ..... **Stratiomyidae**

CC. Radial sector originating well before base of discal cell; vein M_3 usually either not reaching wing margin or closely approaching or fusing with Cu_1 to close cell M_3; at least one pair of tibiae with spurs; males usually dichoptic; scutellum never armed; abdomen with at least seven unreduced segments ..... **Erinnidae**

Rhagionidae (Leptidae). In the restricted sense here adopted, this family is a relatively homogeneous group. I would definitely include the following genera:

Atherix	*Lampromyia*	*Spania*
Atrichops	*Omphalophora*	*Spaniopsis*
Bicalcar	*Paraphoromyia*	*Suragina*
Chrysopilus	*Ptiolina*	*Symphoromyia*
Dasyomma (*Trichopalpus*)	*Rhagina*	*Vermileo*
Dialysis (*Triptotricha*)	*Rhagio* (*Leptis*)	

Wing vein R_5 ends well posterior to the wing tip in the great majority of the Rhagionidae; it is at or a little anterior to the tip in *Spania*, most species of *Ptiolina*, and a few *Symphoromyia*.

Nemestrinidae. Only in this family of all Diptera is the primitive reticulation, called by Tillyard archedictyon, preserved beyond occasional supernumerary crossveins. Consolidation of the flagellar segments, specialization of the wing venation, and development of conical abdomen are characters which may be considered indicative of greater specialization than obtains in the Erinnidae and Coenomyiidae. The Australian genus *Exeretoneura* (*v.* Mackerras 1925) has preserved a thick, annulate flagellum, but its wing venation allies it with the Nemestrinidae. *Trichophthalma*, and some other genera, have a definitely aristate flagellum with two segments at the base of the arista.

There are connections between the Nemestrinidae and the Acroceridae in such genera as *Fallenia* (Nemestrinidae) and *Astomella*, *Eulonchus*, and *Lasia* (Acroceridae).

Acroceridae (Cyrtidae). This is apparently the most highly specialized group of the Tabanoidae, although in the Panopinae, with their generalized wing venation, there is a harkening back to the archedictyon in the presence of sporadic crossveins and varying loci of branching and fusion of veins.

Tabanidae. As here restricted, without some of the forms which have been associated with them, the Tabanidae are also a compact group. As will be seen below, I consider *Coenomyia*, *Pelecorhynchus*, *Bequaertomyia*, and *Heterostomus* to belong to other familes.

Pantophthalmidae (Acanthomeridae). A well set-off group restricted to the American tropics. The taxonomy of the group has been treated by Austen (1923), Greene and Urich (1931) have published on the immature stages, and Thorpe (1934) has written on *Pantophthalmus tabaninus*. J. Pinto da Fonseca (1950) has published an account of *Pantophthalmus pictus* as a pest of trees in Brasil.

Coenomyiidae. This family for a long time was composed of the genus *Coenomyia* alone, because *Coenomyia ferruginea* Scopoli (*C. pallida* Say) happens to possess spines on the scutellum. Enderlein (1922) described a form, *C. bituberculata*, with but rudimentary scutellar spines. I would include in the family the following genera:

Anacanthaspis	*Coenomyia*
Arthroceras	*Glutops*
Arthropeas	*Pelecorhynchus*
Arthroteles	(*Coenura*, *Archeomyia*)
Bequaertomyia	*Stratioleptis*
Bolbomyia	

These genera are distributed in the northern hemisphere, with the exceptions of *Pelecorhynchus*, which is Australian and South American, and *Arthroteles*, which is South African.

Enderlein (1925) gave *Pelecorhynchus* and *Coenura* distinction as subfamily Pelecorhynchinae of the Tabanidae. Bequaert (1930) grouped those two genera with *Coenomyia* as subfamily Coenomyiinae in the same family, remarking that Bigot and Philippi had already associated *Coenura* with *Coenomyia*. Philip (1941) and Hardy (1944) also treated the Pelecorhynchinae as a subfamily of the Tabanidae.

Mackerras and Fuller (1942), in their excellent study of *Pelecorhynchus*, gave that genus (with *Coenura* as a synonym) family rank and remarked in several instances upon resemblances to *Coenomyia*. I have examined the male genitalia of *Coenomyia ferruginea* in a North American example and present figures of dorsal and ventral views comparable to those of *Pelecorhynchus* species given by Mackerras and Fuller. I believe that the transversely elongated "window" in the ventral aspect of the sternite is significant (fig. 1).

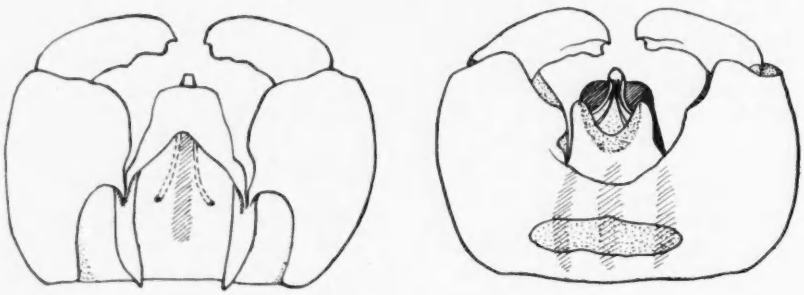

FIG. 1. *Coenomyia ferruginea* Scopoli, from Michigan. Dorsal and ventral views, respectively, of male hypopygium.

I am following Bequaert in associating *Pelecorhynchus* with *Coenomyia*, but I do not believe that the genera I have listed are any more closely related to the Tabanidae than any of the other families are to each other. *Archeomyia* Philip (1941) was erected for *Pelecorhynchus fulvus* Ricardo, an Australian species with dichoptic eyes in the male. *Pelecorhynchus mirabilis* Taylor and *P. distinctus* Taylor are also dichoptic in the male, the latter species, however, only narrowly. I believe that Mackerras and Fuller have abundantly shown that these species are in very close affinity with the other species of *Pelecorhynchus* and that they do not merit generic separation. It may be remarked that a similar set of circumstances exists in the rather extensive genus *Psilocephala* of the Therevidae.

Arthroteles (Bezzi, 1926) was placed by its describer in a new subfamily of the Rhagionidae, but according to its description it is easily placed in the Coenomyiidae.

Stratioleptis (Pleske, 1925) was placed in the Coenomyiidae by its author and this placing was concurred in by Séguy (1926a), who described a second species (1926).

It is likely that some of these genera may be deserving of distinction as types of subfamilies, but I would defer further conclusions regarding the classification of the group until I were able to examine specimens of both sexes of the majority of the genera.

Knowledge of the immature stages is especially scanty in this group; however, *Coenomyia* has been described by Malloch (1917) and Peterson (1951) and *Pelecorhynchus* by Mackerras and Fuller (1942).

Stratiomyidae. One of the largest and most diversified branches of the Tabanoidea is formed by this family. I would include herein the "Chiromyzidae" and *Metoponia* and its relatives, but *Solva* and its allies, which have been placed by some in the Stratiomyidae, are discussed with the Erinnidae. The spelling of the family name is based upon *Stratiomys* (emend. *Stratiomyia*).

Erinnidae (Xylophagidae). The Coenomyiidae and Pantophthalmidae seem to have some relationship with the Tabanidae, but the Erinnidae as distinctly show affinity with the Stratiomyidae. I would include the following genera in the Erinnidae:

Atherimorpha	*Nematoceropsis*
Austroleptis	*Rachicerus*
Erinna (*Xylophagus*)	*Solva* (*Subulonia, Hanauia*)
Heterostomus	*Xylomyia*

Austroleptis apparently finds its best place here; the South American form, *A. fulviceps* Malloch (1932, with figure by Terzi), the type of which I have examined, has wing vein Rs extending well basad of the discal cell, contrary to Terzi's figure. *Atherimorpha*, also of Australia and South America, likewise comes here.

Heterostomus Bigot (*v.* Malloch, 1932, and Kröber, 1930), a South American genus which has been shuffled about from the Bombyliidae to the Rhagionidae and Tabanidae, seems also best placed in the Erinnidae.

Nematoceropsis, placed by its describer (Pleske, 1925) in the subfamily Xylomyiinae of the Erinnidae, along with *Rachicerus* and and *Solva*, seems well placed.

There is little basis for considering a family Rachiceridae (Curran, 1934). The antennae of *Rachicerus* are the most primitive in the Brachycera, but they are only one extreme of a long series in several groups of the Tabanoidea. *Allognosta* ((Stratiomyidae) apparently also has distinctly articulate flagellar segments.

Solva exhibits in its larval and pupal stages characters which in my opinion point to a phylogenetic relationship with the Stratiomyidae but not to actual membership within the family, which is precluded by the adult characters.

I wish to express my sincere gratitude to all of my friends who have assisted and encouraged me in this study, but especially I must mention G. H. Hardy and I. M. Mackerras.

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THE FAMILY CATEGORIES OF TETRANYCHOID MITES, WITH A REVIEW OF THE NEW FAMILIES LINOTETRANIDAE AND TUCKERELLIDAE

EDWARD W. BAKER[1] AND A. EARL PRITCHARD[2]

The development of a classification of the order Acarina has lagged far behind that of orders of insects. Prior to the twentieth century the phylogeny of mites was inadequately understood, and little progress had been made in the actual recognition of species. During the last half-century, however, the comprehensive studies of Oudemans, Vitzthum, and Tärgårdh, in particular, contributed greatly to an understanding of the phylogenetic relationships of mite groups, and a number of students have aided through their detailed characterization of species in some of these groups.

A large number of mite families have been proposed, many based on individual genera or species, and a number of categories above the family rank are recognized. It may be noted that mites occupy as many ecological niches as insects, and their morphological adaptations are extremely diverse.

Many plant-feeding mites that belong to the Tetranychoidea are of agricultural importance, and they have received a considerable amount of study. However, not until 1950 was the last genus of the predaceous Raphignathidae removed from the group. Family concepts of the Tetranychoidea have, therefore, received comparatively little attention.

The present study is a re-evaluation of the tetranychoid family categories, and two new families are proposed. The new families are small and they are considered in detail. A recently proposed genus that is based on a single nymph is also redescribed, inasmuch as it probably represents still another new family. The two large families, the Phytoptipalpidae and the Tetranychidae, are considered in another series of articles.

Tetranychoidea, new superfamily

Mites belonging to the Tetranychoidea are readily distinguished from other prostigmatic mites by having the chelicerae very long, needlelike, strongly recurved proximally, and set in an eversible pouch, the stylophore. They feed on higher, living plants.

Tetranychoid mites were first segregated as a family by Donnadieu (1875), and Canestrini and Fanzago (1878) followed this concept. However, Canestrini (1889) included in the family predaceous mites properly belonging to other prostigmatic families, and this practice was followed by a number of subsequent workers such as Banks (1915) and Vitzthum

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(1929, 1942). McGregor (1950) removed the last of the raphignathid genera (*Neophyllobius* Berlese) that had been erroneously included.

The family Phytoptipalpidae was proposed by Ewing (1922) for an aberrant tetranychoid mite from India. Oudemans (1928) and Sayed (1938, 1950) proposed family names for closely related genera. The separate family concepts, however, were broadened by Sayed (1942, 1950) and Baker (1945), and Ewing's name was restored for the entire group (Pritchard and Baker, 1952).

The new family Linotetranidae is based on a genus that has been erroneously assigned to the (Stigmaeidae) = Raphignathidae, and the new family Tuckerellidae is based on a genus that was assigned to the Tetranychidae.

The following key is presented as a ready means of separating the families, but it should not be construed as indicating the more important familial characters. For example, the absence of eyes can be used as a simple means of separating the Linotetranidae from the other families, although other characters are more basic and will probably have to be used eventually.

Family characters in the Acarina may occur in the tracheal system, chelicerae, palpi, tarsal sensory organs and appendages, arrangement and number of body setae, and genital systems. These characters have proved to be constant, or variable only to a limited degree, within the families of mites now recognized. To the entomologist who is used to dealing with the highly specialized genital systems such as found in the Lepidoptera, these characters may appear to be of secondary importance. However, studies by Trägårdh on the relationships within the Mesostigmata have shown the basic importance of setal patterns, and genital structures and arrangements, however minute they might appear to be.

KEY TO FAMILIES

1. Palpus with fourth segment bearing a strong, curved spur 2
   Palpus simple, without a spur ..... **Phytoptipalpidae**
2. Eyes present 3
   Eyes absent ..... **Linotetranidae**
3. Hysterosomal dorsum with 36 fanshaped setae, the caudal end with a series of flagelliform setae ..... **Tuckerellidae**
   Hysterosomal dorsum with not more than 24 setae, the caudal end without a series of flagellate setae ..... **Tetranychidae**

Family **Phytoptipalpidae** Ewing

PHYTOPTIPALPIDAE Ewing, 1922, Proc. Ent. Soc. Washington, 24: 107; Pritchard and Baker, 1952, Univ. Calif. Press Publ. Ent. 9(1): 2; Baker and Wharton, 1952, An Introduction to Acarology, p. 220.

PHYTOPTIPALPINAE Sayed, 1950, Proc. Eighth Internatl. Congress Ent., p. 1016.

PSEUDOLEPTIDAE Oudemans, 1928, Ent. Ber., 7: 287; Vitzthum, 1942, Klass. Ordn. Tierr., 5 (Abt. 4, Buch 5): 811; McGregor, 1949, Mem. S. Calif. Acad. Sci., 3(2): 1; Baker, 1949, Amer. Midl. Nat., 42: 352; Radford, 1950, Internatl. Union Biol. Sci., Sér. C. (Sect. Ent.), 1: 80.

TRICHADENIDAE Oudemans, 1938, Tijd. Ent., 81: lxxv; Womersley, 1940, Trans. Roy. Soc. S. Austr., 64: 263; Baker, 1945, Proc. Ent. Soc. Washington, 47: 33; Sayed, 1946, Bull. Soc. Fouad 1er Entom., 30: 99.

PSEUDOTETRANYCHINAE Sayed, 1938, Bull. Mus. Natl. Hist. Nat. (ser. 2), 10: 602; Sayed, 1942, Bull. Soc. Fouad 1er Ent., 36: 81.

TENUIPALPIDAE Sayed, 1950, Proc. Eighth Internatl. Congress Ent., p. 1015.

TENUIPALPINAE Sayed, 1950, Proc. Eighth Internatl. Congress Ent., p. 1016.

The family Phytoptipalpidae is readily distinguished from other tetranychoid mites by having the palpus simple, the penultimate segment bearing no spur. The terminal segment of the palpus is distinctive in that it bears a rodlike sensory process and no more than one or two sensory setae and no tactile setae. There are often less than five palpal segments, a condition that is not found elsewhere in the Tetranychoidea.

The propodosoma bears three pairs of dorsal setae. The dorsal hysterosomals form a unique pattern, although they vary in number from 9 to 13 pairs and their arrangement varies to some extent.

The genital plate of the female is distinctive in that it is well developed, transversely elliptical, and provided with two (very rarely one) pairs of setae. A ventral plate is usually present.

The phallic organs of the male consist of a pair of sclerotized, simple, genital stylets; the sperm sac is weakly sclerotized, and the sperm duct enters a funnel-shaped opening that narrows to a form a needlelike aedeagus.

The phytoptipalpids constitute a homogeneous group. North American genera and species occurring in California were considered in a recent paper (Pritchard and Baker, 1952). A comprehensive treatment of the genera and a catalogue of the species is being presented elsewhere.

Linotetranidae, new family

Type of Family: Genus *Linotetranus* Berlese.

The family Linotetranidae may be readily distinguished from other tetranychoid families by lacking eyes.

The anterior end of the propodosoma bears a cone-shaped, ribbed invagination similar to that of the Phytoptipalpidae, and the sensory pegs of tarsus I and tarsus II are as in that family. However, the fourth palpal segment bears a strong spur as in the other tetranychoid families. The fifth palpal segment is distinctive by bearing a terminal sensory peg and five setae (two sensory and three tactile).

The chaetotaxy of the dorsum of the body is unique. The propodosoma bears four pairs of setae, and the hysterosoma bears 17 or 18 pairs of setae.

The genital plate of the female is distinctive in that it is triangular (the apex extending anteriorly under the caudal margin of the ventral plate), longitudinally divided, and provided with three pairs of setae.

The phallic organs of the male are distinctive in that they consist of a pair of strongly recurved genital stylets, and a slender, sclerotized aedeagus; the sperm sac is weakly sclerotized, and the sperm duct enters the slender apodeme of the aedeagus. There are six pairs of of genito-anal setae, whereas only three or four pairs are known in other tetranychoids.

Genus **Linotetranus** Berlese

Linotetranus Berlese, 1910, Redia, 6: 208.

Type of genus: *L. cylindricus* Berlese; monobasic and by original designation.

Linotetranus was based on a single species that has been unrecognized until now. Although Berlese clearly indicated in his description and

figure that the genus is allied to *Tetranychus*, subsequent European workers have regarded it as a member of the family (Stigmaeidae) = Raphignathidae.

KEY TO SPECIES

Caudal division of dorsum of opisthosoma with eight pairs of setae. . **cylindricus**
Caudal division of dorsum of opisthosoma with seven pairs of setae, the anterolateral pair present . . . . . **achrous**

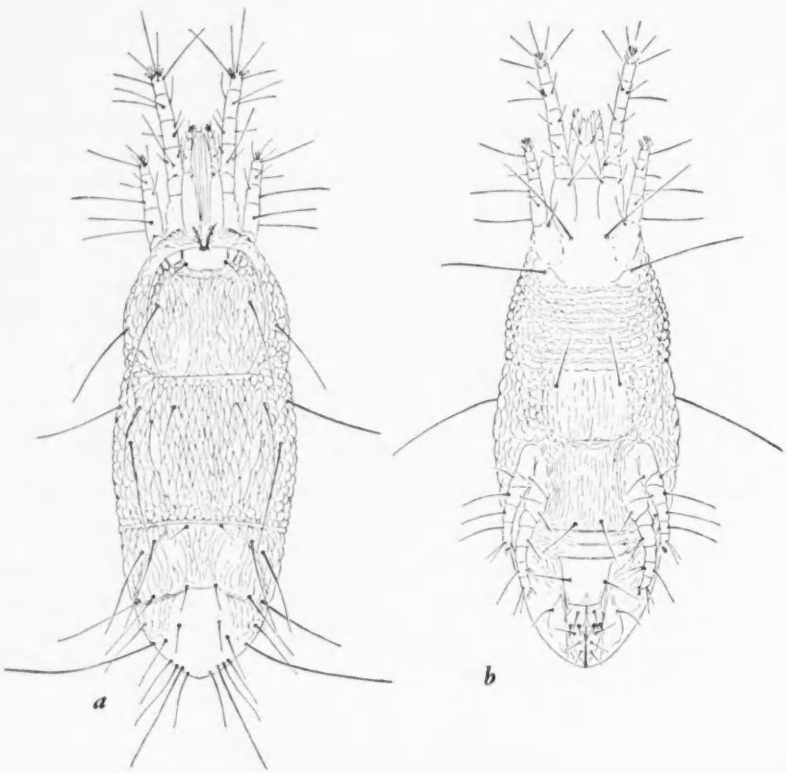

FIG. 1. *Linotetranus cylindricus:* a, dorsal aspect of female; b, ventral aspect of female.

Linotetranus cylindricus Berlese

(Figs. 1, 2)

Linotetranus cylindricus Berlese, 1910, Redia, 6: 208 (fig. dorsum of female).
Type: Female, Panormitani, Italy, from moss; in the Berlese Collection of the R. Stazione di Entomologica Agraria, Florence, Italy.

Female.—Rostrum slender, reaching middle of genu I. Palpus with dorsal seta on each of segments two, three, and four; segment four with strong claw; segment five slender but only slightly longer than claw, bearing a curved sensory peg dorsally, two slender sensory

setae distally, and three tactile setae. Legs I and II with genua, tibiae, and tarsi each slightly decreasing in length; tarsus I with two distal, short and spindle-shaped, sensory rods; tarsus II with a single spindle-shaped rod; true claw padlike with a ventral, double row of tenent hairs; empodium similar to claw. Propodosomal dorsum with fine, longitudinal striations except for transverse striae anteriorly; four pairs of

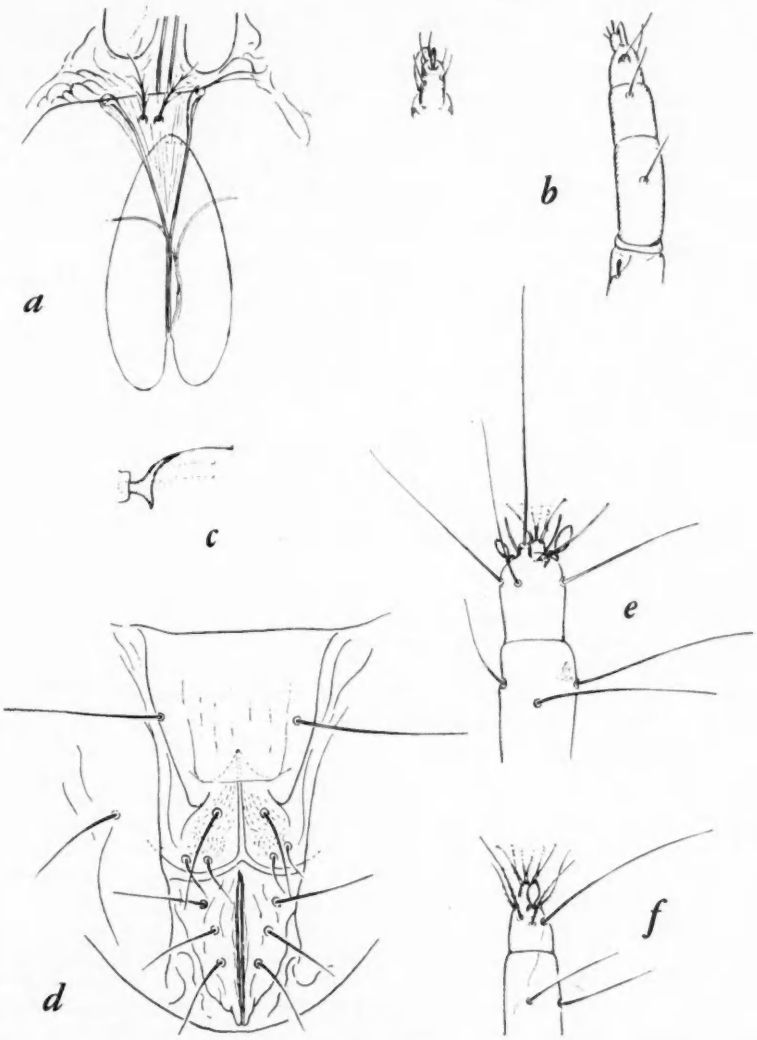

FIG. 2. *Linotetranus cylindricus:* a, dorsal aspect of stylophore and respiratory system; b, palpus; c, claw; d, ventral aspect of female opisthosoma; e, dorsal aspect of tarsus I; f, dorsal aspect of tarsus II.

dorsal propodosomals, the anterior pair pinnate, the others setiform with the second pair much shorter than the third and fourth. Hysterosomal dorsum with fine, anastomosing, longitudinal lines, metapodosoma separated by transverse lines; metapodosoma separated by transverse lines and opisthosoma transversely divided medially. Metapodosomal dorsum with three pairs of slender setae along anterior end and with one pair of similar setae mediolaterally. Opisthosomal dorsum with a row of six slender setae anteriorly and a row of six slender setae posteriorly on anterior portion; posterior portion with four pairs of setae anteriorly and four pairs of caudolateral setae. Opisthosoma ventrally with a ventral plate bearing a pair of setae, a triangular, longitudinally divided genital plate with three pairs of setae, a pair of mediolateral setae, and three pairs of anal setae. Length of body 400 μ, including rostrum 500 μ; greatest width of body 166 μ.

The redescription is based on two females, Monte Crista, Utah, July 20, 1949 (G. F. Knowlton and Shi-chun Ma), from rotting alpine fir.

Dr. G. Lombardini compared the accompanying illustration with Berlese's type and wrote that, "Sono persuaso che la figure mi hai mandato corrispondono al *Linotetranus cylindricus* Berl. Nella figura del Berlese non appare striatura, ma l'acro ce l'ha."

It is possible that the genus *Linotetranus* contains a number of species that resemble each other very closely, and future studies of males may indicate that the Utah specimens are specifically distinct from the type from Italy.

Linotetranus achrous, n. sp.

(Figs. 3, 4)

L. achrous differs from *L. cylindricus* (as here identified) principally in lacking the first pair of anterolateral setae on the caudal division of the opisthosomal dorsum.

Male.—Rostrum slender, reaching proximal portion of genu I. Palpus with dorsal seta on each of segments two, three, and four; fifth segment with curved sensory peg, two slender sensory setae, and three tactile setae. Legs I and II with genua, tibiae, and tarsi each slightly decreasing in length; tarsus I with two spindle-shaped sensory pegs distally; tarsus II, III, and IV each with a single, spindle-shaped sensory peg distally; claw without hook, the outer tenent hairs slightly longer than inner row; empodium as long as claws, padlike, with a double, ventral row of tenent hairs. Propodosoma with fine, rather sparse, mostly longitudinal striae; four pairs of setiform dorsal propodosomals, the anterior pair sparsely pinnate, the second pair sparsely serrate, the third and fourth pairs very long and minutely serrate. Metapodosomal dorsum with sparse, longitudinal striae; with an anterior row of six setae and another pair of sublateral setae, the more lateral setae longer. Opisthosomal dorsum with longitudinal striae medioanteriorly and with transverse striae medially; with a transverse row of six setae along anterior margin, with a transverse row of six setae medially, and with seven pairs of setae caudally; the most lateral setae longer than others. Metapodosoma with anterior pair of medioventrals similar in length to posterior pair. Opisthosoma with medioventrals situated near middle of segment, similar in length to para-anals; genito-

anal papilla large with six pairs of short setae; genital stylets stout, curved ventrad to form a semicircle, distally with a small anterior barb and an acuminate terminal projection. Length of body 290 μ, including rostrum 353 μ; greatest width of body 133 μ.

Female.—Gnathosoma, legs I and II, dorsal striations of idiosoma and dorsal chaetotaxy similar to male. Tarsi III and IV without

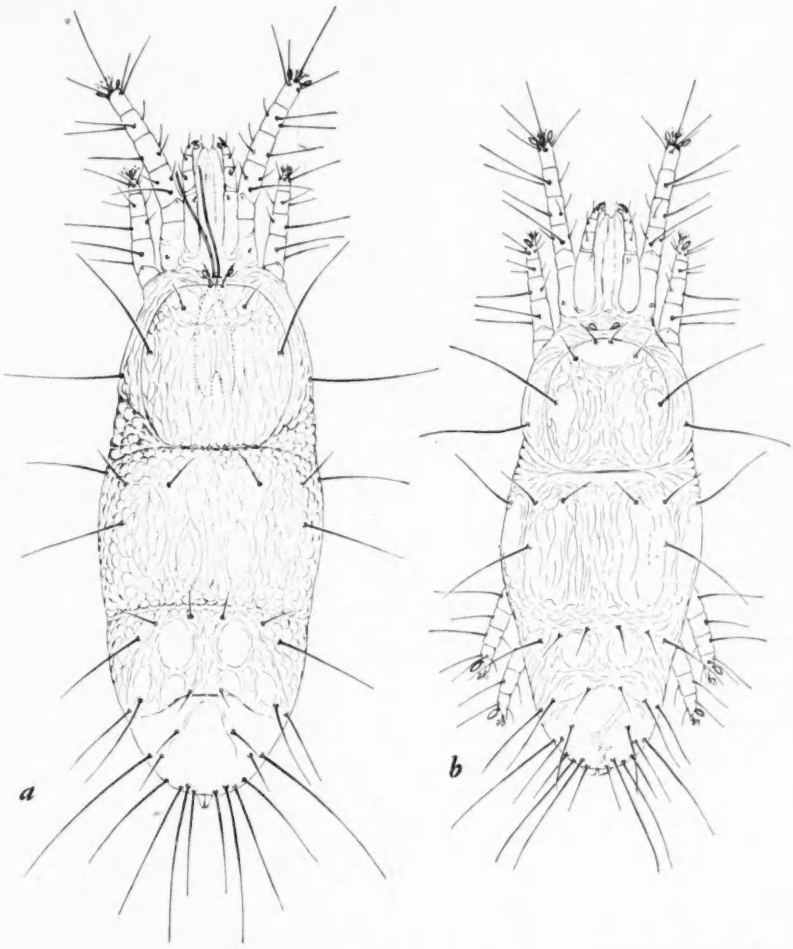

FIG. 3. *Linotetranus achrous:* a, dorsal aspect of female; b, dorsal aspect of male.

sensory pegs. Opisthosoma with a pair of setae on ventral plate, three pairs of setae on the triangular, longitudinally divided genital plate, a pair of mediolateral setae on venter, and three pairs of anal setae. Length of body 372 μ, including rostrum 466 μ; greatest width of body 166 μ.

Nymph.—Similar to female except for genital characters.

Holotype.—Male, Tesla, California, October 4, 1951 (J. E. Gillaspy), on *Distichlis spicata;* in the U. S. National Museum (type no. 1982).

Paratypes.—One male, 18 females, 10 nymphs, Tesla, California, October 4, 1951 (J. E. Gillaspy), on *Distichlis spicata.*

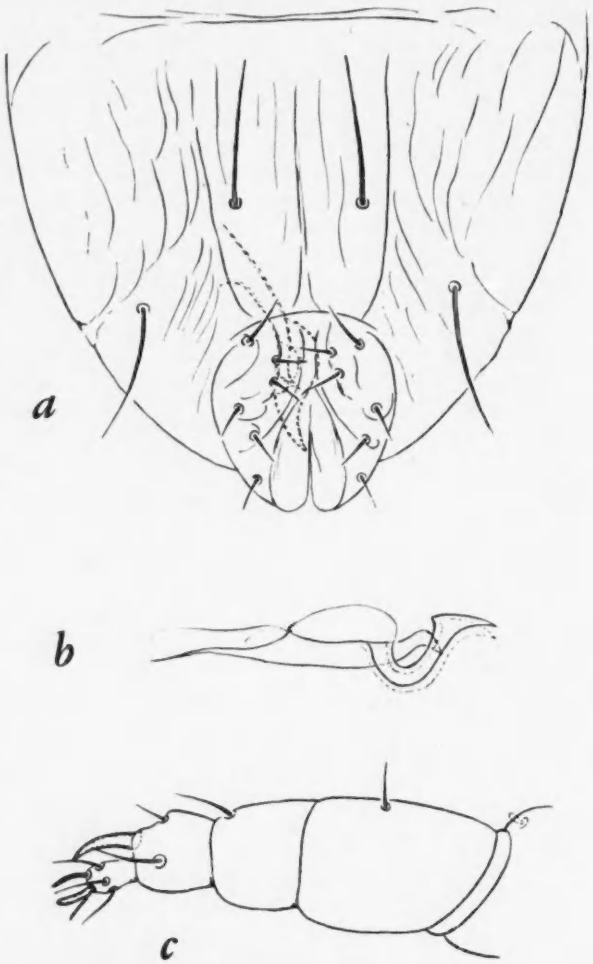

FIG. 4. *Linotetranus achrous:* a, ventral aspect of male opisthosoma; b, lateral aspect of male genitalia; c, male palpus.

Tuckerellidae, new family

Type of Family: Genus *Tuckerella* Womersley.

The family Tuckerellidae is readily distinguished from other tetranychoid mites by the dorsal chaetotaxy of the body. Known species

have four pairs of fan-like dorsal propodosomals and 36 pairs of fan-like dorsal hysterosomals. There are also five or six pairs of flagellate setae caudally. The dorsal integument of the body is reticulate.

The palpus of a tuckerellid is distinctive in that the fifth segment is long and slender and bears only two sensory rods and three tactile setae. A slender, curved spur is present on segment four.

Tarsi I and II each bears one or two distal sensory rods as in the phytoptipalpids and linotetranids.

The female bears no genital plate nor ventral plate. On each side of the folds of the vulva are three pairs of setae (two genital and one mediolateral), and anterior to the folds of the oviduct are the two pairs of ventral setae—the medioventral pair of setae are just anterior to these.

The male is unknown.

The family Tuckerellidae includes a single genus.

Genus **Tuckerella** Womersley

Tuckerella Womersley, 1940, Trans. Roy. Soc. S. Austr., 64: 244.
Type of genus: *Tenuipalpus ornatus* Tucker; monobasic.

Tuckerella is a genus of odd, plant-feeding mites of which only two species are known.

Womersley proposed the genus *Tuckerella* for specimens of *pavoniformis* that he misidentified as *Tenuipalpus ornata* Tucker. There is no question as to the validity of the generic name, inasmuch as Womersley's specimens represent a species very closely allied to the nominal type of the genus, and we accept the nominal type.

KEY TO SPECIES

Caudum with six pairs of whiplike setae.....**pavoniformis**
Caudum with five pairs of whiplike setae.....**ornata**

Tuckerella ornata (Tucker)

(Figs. 5, 6)

Tenuipalpus ornatus Tucker, 1926, Union S. Afr., Dept. Agr., Div. Ent. Mem., 5: 4 (fig. caudal end of body, tarsal appendages, and rostrum).
Cotypes: Two females, Western Cape Province, Africa, on orange; disposition unknown.

McGregor (1950) considered *ornata* to be a synonym of *pavoniformis*, but this synonymy cannot be accepted.

Tuckerella ornata may be recognized by having five pairs of flagellate setae caudally, but the species is also distinctive in other respects.

The anterodistal sensory rod on tarsus I is as long as, but slenderer than, the posterodistal sensory rod. Tarsus II bears a slender sensory rod anterodistally. Leg IV bears slender setae dorsally.

The last four palmate hairs on the dorsum of the body have the outer pair smaller than the inner pair, and they are placed caudad of the inner pair.

T. ornata was originally described from orange fruits in Western Cape Province and Transvaal, Africa. We have studied specimens from Natal, on citrus.

Additional material has been received from Coconut Grove, Florida, Jan. 24, 1923 (E. L. Kelly), on *Bauhenia* sp., and Nov. 1, 1950 (H. Y.

Gouldman), on *Hevea* cuttings (at Washington, D. C. Quarantine); from San Jose, Guatemala, June 14, 1951 (E. B. Francis), on *Mammea americana* fruit (at San Diego, Calif. Quarantine); from the Philippine Islands, May 29, 1945 (A. Kolb), on *Phalaenopsis* sp. (San Francisco, Calif. Quarantine).

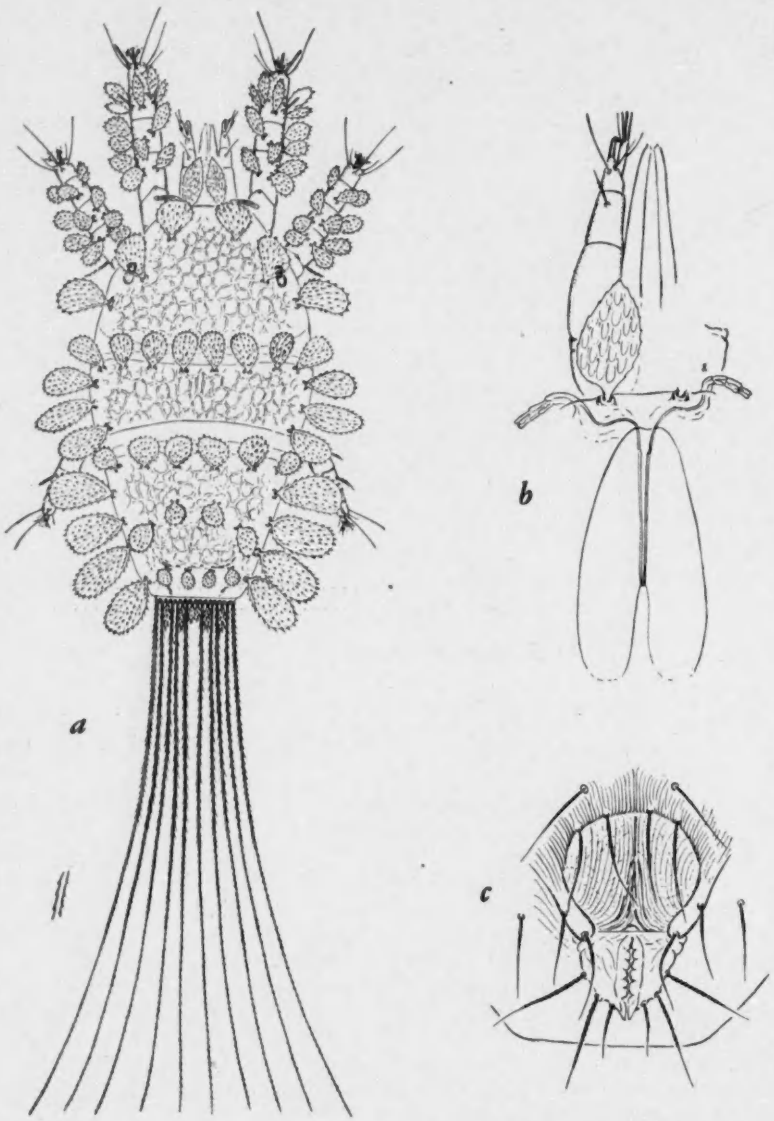

FIG. 5. *Tuckerella ornata:* a, dorsal aspect of female; b, dorsal aspect of gnathosoma and stylophore; c, ventral aspect of female opisthosoma.

Tuckerella pavoniformis (Ewing)

(Figs. 6, 7)

Eupalopsis pavoniformis Ewing, 1922, Proc. Ent. Soc. Washington, 24: 106. Type: Female, Hawaii, on *Hibiscus* (California Quarantine); in the U. S. National Museum.

Tuckerella ornata Womersley, 1940, Trans. Roy. Ent. Soc. S. Austr., 64: 244 (fig. female dorsum and venter, palpus). Misidentification.

Tuckerella pavoniformis McGregor, 1950, Amer. Midl. Nat., 44: 368 (fig. dorsal aspect of female, palpus, eyes, end of trachea, and tarsal appendages).

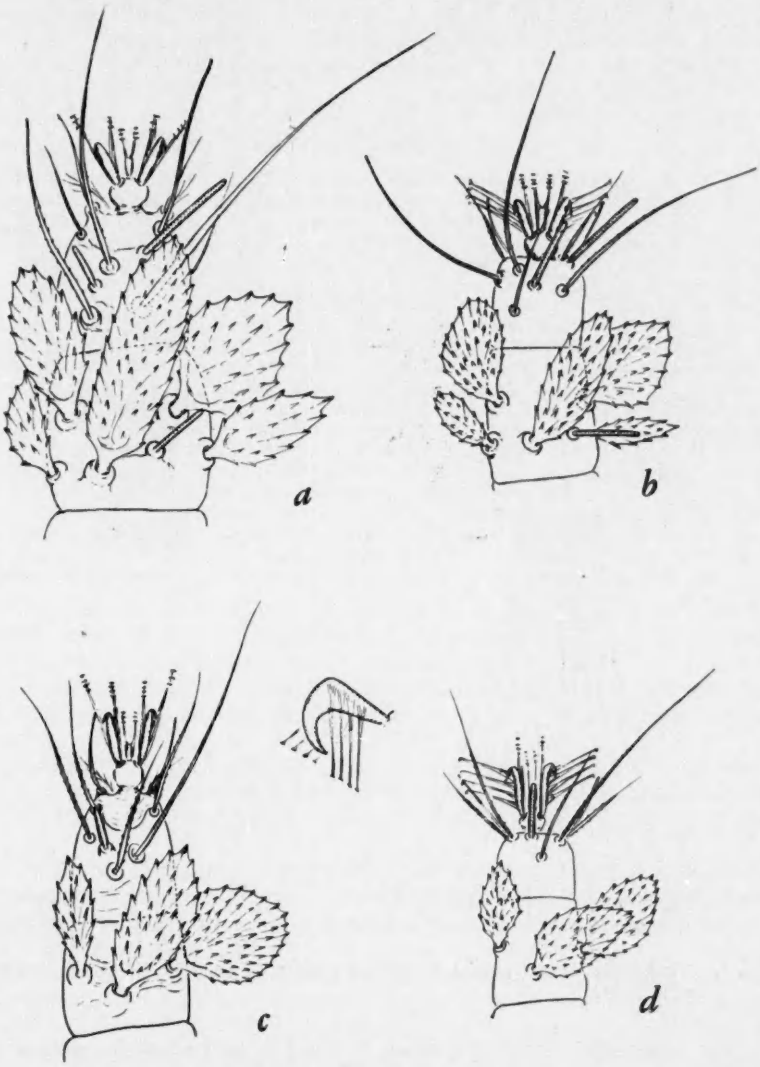

FIG. 6. *Tuckerella pavoniformis:* a, dorsal aspect of tarsus I; c, dorsal aspect of tarsus II. *Tuckerella ornata:* b, dorsal aspect of tarsus I, with lateral view of claw; d, dorsal aspect of tarsus II.

Tuckerella pavoniformis may be recognized by having six pairs of flagellate setae caudally. However, this species is distinctive with regard to other characters.

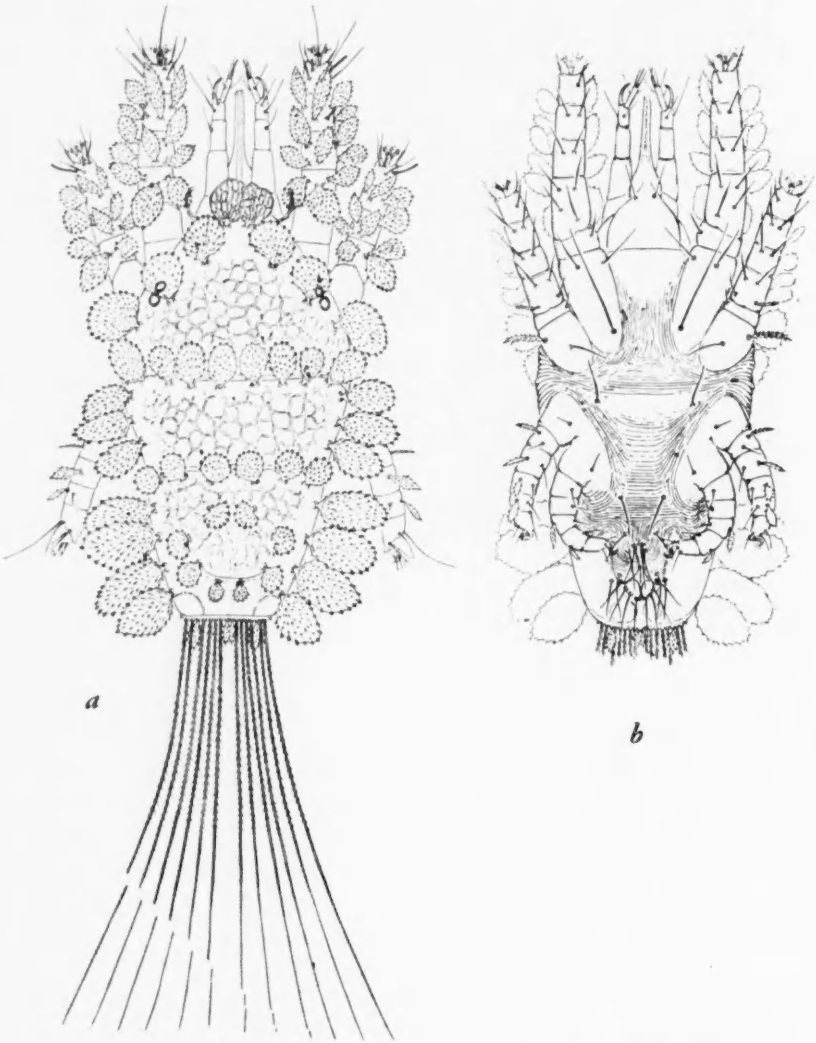

FIG. 7. *Tuckerella pavoniformis:* a, dorsal aspect of female; b, ventral aspect of female.

The anterodistal sensory rod on tarsus I is very short in comparison to the posterodistal sensory rod. Tarsus II bears a short sensory peg anterodistally. Leg IV bears large, strongly serrate setae dorsally.

The last four palmate hairs on the dorsum of the body have the outer pair larger than the inner pair, and they are placed anterior to the inner pair.

T. pavoniformis was described from Hawaii (at Quarantine, San Francisco, Calif.) on hibiscus. Womersley's records from Australian citrus, cypress pine, eucalyptus, and privet apply to this species. Specimens examined by us (other than the type) are from Kailau, Oahu, Hawaii, March 26, 1941 (W. C. Look), on papaya fruit; Hawaii (at Quarantine, San Francisco, Calif.), April 2, 1941 (F. J. Phelan) on hibiscus; Hawaii (at Quarantine, San Francisco, Calif.), Sept. 4, 1947 (E. V. Lehner) on hibiscus; Los Angeles, Calif., June 14, 1934 (H. H. Keifer) on hibiscus.

Family **Tetranychidae** Donnadieu

TÉTRANYCHIDÉS Donnadieu, 1875, Recher. Serv. Hist. Tétranych., p. 9.

TETRANYCHIDAE Murray, 1877, Economic Entomology, Aptera (South Kensington Museum Science Handbook), pp. 93, 97; Kramer, 1877, Archiv. f. Naturges., 43(2): 225, 228; Trouessart, 1891, Revue des Sci. Nat. de l'Ouest, 1: 289, 308; Berlese, 1897, Acari, Myr. Scorp. Prostigmata, pp. 7, 8, 51; Oudemans, 1897, Tijd. Ent., 40: 120; Banks, 1900, U. S. D. A., Div. Ent. Tech. Ser., 8: 70; Banks, 1907, Proc. U. S. Nat. Mus., 32: 598; Ewing, 1909, Univ. Ill. Bull., 7(14): 35; Oudemans, 1910, Bull. Ent. Res., 1: 113; Banks, 1915, U. S. D. A. Report, 108: 32; Ewing, 1929, A Manual of External Parasites, pp. 20, 28; Vitzthum, 1929, Tierw. Mitteleur., 3 (Lief 7): 473; Vitzthum, 1931, Handb. Zool., 3 (Lief 1, Teil 3): 145; Geijskes, 1939, Meded. Landbouwh. Wageningen, 42(4): 11; Garman, 1940, Conn. Agric. Expt. Sta. Bull., 431: 67; Womersley, 1940, Trans. Roy. Soc. S. Austr., 64(2): 234; Vitzthum, 1942, Klass. Ordn. Tierr., 5 (Abt. 4, Buch 5): 809; McGregor, 1950, Amer. Midl. Nat., 44(2):257; Radford, 1950, Internatl. Union Biol. Sci., Sér C (Sect. Ent.) 1: 76; Baker and Wharton, 1952, An Introduction to Acarology, p. 211.

TETRANYCHINI Canestrini and Fanzago, 1878, Atti Reale Ist. Veneto Sci. Let. Arti, (ser 5) 4: 148; Canestrini, 1889, Atti Reale Ist. Veneto Sci. Let. Arti, (ser 6) 7: 62; Canestrini, 1890, Prospetto dell'Acarofauna Italiana, IV: 427.

TETRANYCHINA Berlese, 1886, Acari Dannosi alle Piante Coltivate, Padova.

The taxonomic revisions of Trägårdh (1915), McGregor (1919), Zacher (1916, 1933), and Ugarov and Nikolskii (1937) were all written with reference to the family only by a common name.

The family Tetranychidae may be differentiated from other tetranychoid families by having duplex setae (and not distal sensory pegs) on tarsi I and II.

Segment four of the palpus bears a very strong spur. The terminal segment is short and broad, and it bears four sensory setae and three tactile setae. The stylophore is shorter and broader than in the other families.

The dorsal chaetotaxy is of a distinctive type, although there may be translocation of the setae and several may be lost. There are three or four pairs of dorsal propodosomals, and the hysterosoma possesses from 9 to 12 pairs of setae.

The ovipositor is distinctive. There are radiate wrinkles around the vulva with a pair of setae immediately anterior and a pair of setae laterad. The medioventral opisthosomals are present but not associated with the genitalia. There are two or three pairs of anal setae, a pair of para-anals, and a pair of postanals.

The male genitalia are also distinctive, consisting of a simple,

sclerotized aedeagus, the slender apodeme of which receives the sperm duct. Genital stylets are absent.

The family Tetranychidae is rather large, containing about 100 species in North America. A revision of the classification of this family is being presented in another paper.

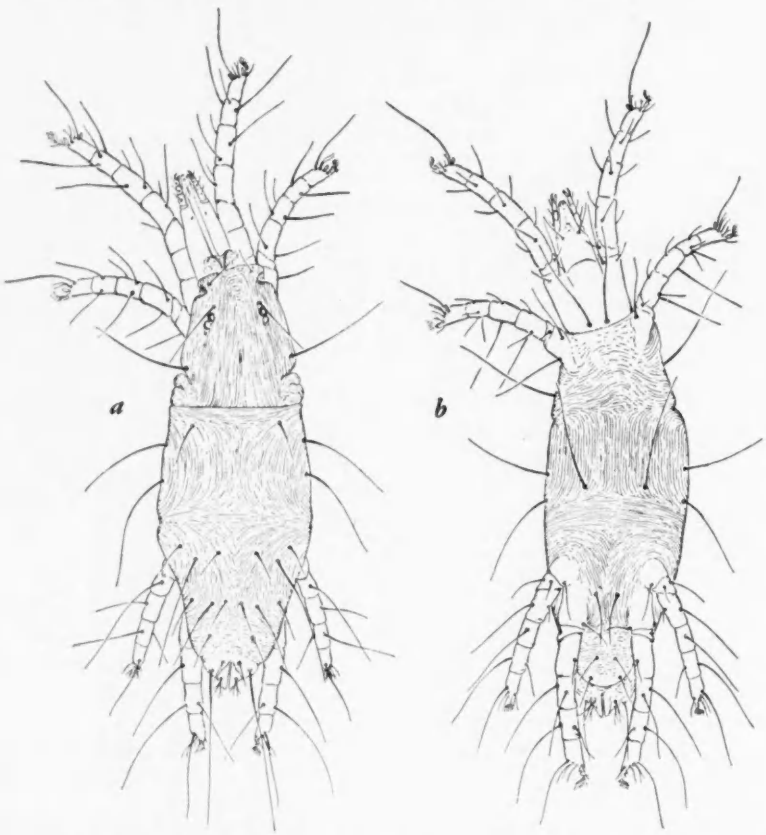

FIG. 8. *Allochaetophora californica:* a, dorsal aspect of nymph; b, ventral aspect of nymph.

However, the genus *Allochaetophora* McGregor appears to be distinct from the tetranychids, and it is here recharacterized. *Allochaetophora* was proposed for a single species that is known from a single nymph. We are reluctant to propose a family based on this genus until the adults are known and the relationships can be clarified.

Allochaetophora californica McGregor

(Figs. 8, 9)

Allochaetophora californica McGregor, 1950, Amer. Midl. Nat., **44**: 371 (fig. lateral aspect of nymph, palpus and tarsal appendages).
Type: Nymph, Redlands, California, on Bermuda grass; in the U. S. National Museum.

This species differs from those belonging to the Tetranychidae and resembles other tetranychoid families by lacking duplex setae and possessing sensory pegs distally on tarsi I and II. The very slender rostrum and stylophore are also characteristic of the other tetranychoids.

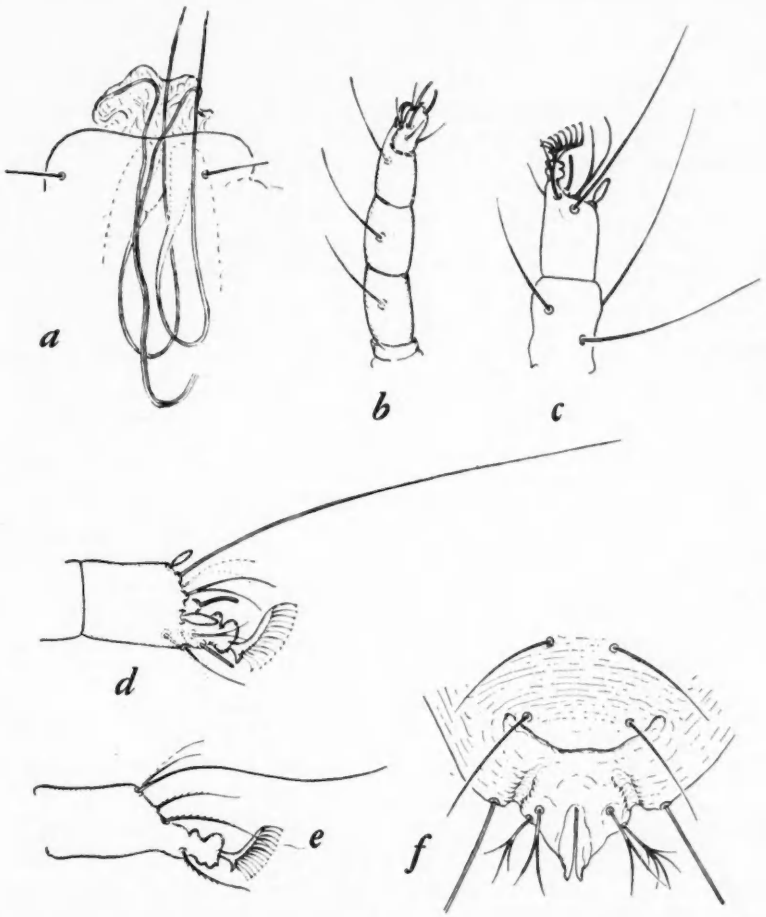

FIG. 9. *Allochaetophora californica:* a, dorsal aspect of respiratory system of nymph; b, palpus of nymph; c, tarsus II of nymph; d, tarsus I of nymph; e, tarsus IV of nymph; f, venter of nymph (transverse line anterior to anus represents an integumental fold).

Allochaetophora differs from the phytoptipalpids by possessing a curved spur on the fourth palpal segment; from the linotetranids by possessing eyes; and from the tuckerellids by the simplified dorsal chaetotaxy.

There are three pairs of dorsal propodosomal setae, ten pairs of dorsal hysterosomals, and three pairs of anal setae.

Allochaetophora californica feeds on grasses, and it has a very slender body superficially resembling the grass-feeding phytoptipalpids and linotetranids. It will be interesting to learn, when the adults are known, whether the relationships are closer to these families or to the Tetranychidae where it was assigned.

ACKNOWLEDGMENTS

We are grateful to Francis M. Summers for permitting us to study the specimens collected by G. F. Knowlton and Shi-chun Ma, and to G. Lombardini for comparing drawings of these specimens with *Linotetranus cylindricus* Berlese.

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NOTES ON NEOTROPICAL TABANIDAE (DIPTERA) WITH DESCRIPTIONS OF NEW SPECIES[1]

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The species discussed here have mostly been taken in Panama as a by-product of work on the ecology of forest mosquitoes being carried on by members of this laboratory, or by survey units working under Lt. Col. F. S. Blanton in connection with his studies of biting midges. The new species or new records for Panama raise the number of species now definitely known from the Republic to 117. The description of a new species from Surinam and revised keys to some genera are also included.

Chrysops laeta Fabricius

1805, Syst. Antl., p. 112. Krōber, 1925, Konowia, 4(3–4): 338–341, and figs.; 1934, Rev. Ent., 4(2): 227. Stone, 1947, Bol. Ent. Venezolana, 3(3): 126 (Venezuela). Carrera and Lane, 1945, Arq. Mus. Paranaense, 4(4): 129 (Parana, Brasil). Bequaert and Rengifo, 1946, Psyche, 53(3–4): 57 (Colombia). Anduze, Vogelsang and Pifano, 1947, Bol. Ent. Venezolana, 6, extra number, p. 7 (Venezuela).

A single female specimen from Almirante, Bocas del Toro Province, Panama,2 Oct. 1951, taken in a Shannon trap at ground level. Krober (1925 *l.c.*) listed this species from Costa Rica, a record which long seemed to me dubious in view of the South American distribution of the species, but a number of both animals and plants of South American species seem to occur in Costa Rica with no evidence of their presence in Panama. The specimen differs from Colombian examples (Villavicencio) before me, and from Krōber's figures, in having the apical spot quite dilute and not sharply marked off from the adjacent hyaline wing apex. Krōber (1934 *l.c.*) has given complete references, and I add only those subsequent to 1934.

Chrysops melaena Hine

Fairchild, 1942, Proc. Ent. Soc. Washington, 44(1): 3, fig. 2 (♀; full references). Woke, 1947, Am. J. Trop. Med., 27(3): 368 (Nicaragua).

The male appears to be so far undescribed. Eyes bare, holoptic, but the line of contact short, the frontal triangle elongate. Eyes not greatly enlarged, the area of large facets about half the total eye area, clearly demarkated from the small facets. Antennae about as in female, though the second and third joints a little more slender and darker. Frontoclypeus and genae shiny yellow, the subantennal tuberosities strongly inflated. Palpi black. Thorax and legs as in female, the former wholly black and with sparser vestiture. Wings as in female, except that the basal cells are almost wholly black, with only a small clear spot at apex, and the anal cell is black with a small clear area in the middle. The abdomen is as in the female, except

[1]Costs of publication are paid by the Gorgas Memorial Laboratory.

that the lateral yellow patches and the median yellow triangle on the second tergite are much reduced in size, and the triangles on succeeding tergites smaller than in female.

Neoallotype male, Hermita, Panama, 18 Sept., 1952, in mosquito light trap. F. S. Blankton, coll.

Fidena trapidoi sp. nov.

Plate I, fig. 1

Female.—Length 17—18 mm., of wing 15—17 mm. Frons rather broad, parallel sided, about three times as high as wide, brownish black pollinose and with rather dense short black hairs. Ocelli prominent. Eyes densely short-black-pubescent, the hairs longer and paler towards the lower margin. Subcallus pollinose, concolorous with the frons. Frontoclypeus black, conically produced, blackish pollinose above, shiny below and at the sides, without prominent erect hairs. Antennae black, the first two segments with very short and sparse black hairs, almost nude, but black pollinose, the third segment with the basal annuli quite wide and flattened, the terminal annuli rather short and thick. Second palpal segment black, flattened, broad basally, the apex drawn out into a slender point. First palpal segment nearly as long as the second, slender and cylindrical. Proboscis black, slender, hardly as long as abdomen, the labella slender, sclerotized and fused with the theca. Beard dense and long, creamy white.

Thorax black and mostly black pollinose and densely black haired. There are a few scattered creamy hairs on the anterior margin of the mesonotum and before the wing bases, a small tuft of creamy hairs below the squamulae, and a large prominent tuft of snow white hairs on each side of the black scutellum. The legs are wholly black and black haired, the hairs denser on the femora. The tarsi are dark brown, golden rufous pubescent beneath. The wings have the first posterior cell generally open, usually narrowed, occasionally closed at the margin, the third vein with or without a short appendix. The wings are nearly black at base, heavily fumose in the basal cells and anal area, brownish in costal, marginal and first submarginal cells in the region of the slender yellowish brown stigma, the cross veins with well defined blackish clouds, and the remainder of the wing greyish hyaline or faintly fumose.

The abdomen is black in ground color, the first tergite black haired. The second tergite bears a large median, roughly triangular patch of shiny golden hairs which reaches the anterior border of the segment and the sides are broadly golden haired. The third tergite is more extensively golden haired, having but two dorsolateral anterior patches of black hairs. The remaining tergites are almost wholly

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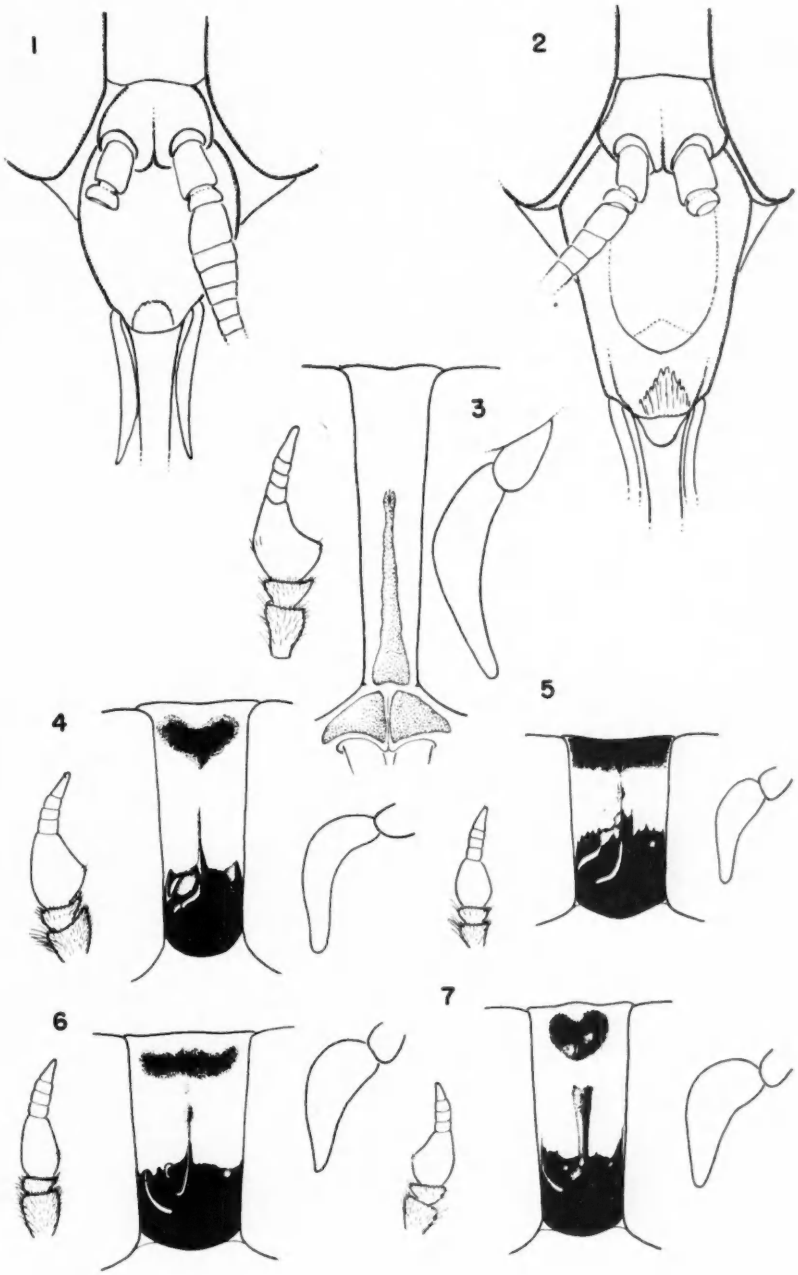
EXPLANATION OF PLATE I

FIG. 1. *Fidena trapidoi* n. sp., lower part of frons and frontoclypeus. FIG. 2. *Fidena howardi* Fchld., same structures. FIG. 3. *Stenotabanus atopus* n. sp. Holotype: frons, antenna and palp. FIG. 4. *St. pompholyx* n. sp. Holotype: frons, antenna and palp. FIG. 5. *St. blantoni* n. sp. Holotype: frons, antenna and palp. FIG. 6. *St. littoreus* Hine, frons, antenna and palp. FIG. 7. *St. geijskesi* n. sp. Holotype: frons, antenna and palp.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golden haired. Beneath, the first sternite and anterior margin of the second are black haired, the remainder of the sternites wholly pale golden haired.

Holotype female, Almirante, Bocas del Toro Province, Panama, 9 June, 1951. Taken at ground level at Yellow Fever station D.

Paratypes, 34 females, same locality as holotype taken in June (26) and July (1) 1951 and May (7) 1952. Of these, 16 specimens were taken in the forest canopy at platforms built in the trees from 36 to 54 feet above ground level, while 18 were taken attacking man at ground level or in a Shannon trap.

This very striking species is not likely to be confused with any other in Panama, its closest relative being *F. howardi* Fchld. From this it differs in the much broader third antennal segment, in lacking erect hairs on the clypeus, in broader palpi, less produced face, darker wings and in having prominent tufts of white hairs on each side of the scutellum. Named for my colleague, Dr. Harold Trapido, through whose efforts this and many other fine tabanids have been secured.

I give below a key to the Central American species of *Fidena*. I have seen all species except *fulvosericea* Kröber and have seen Central American specimens of all but *fulvosericea* and *gracilis*. These two species probably enter Central America, if at all, only in eastern Panama. There seem no stable characters to separate *rhinophora* Bell and *pyrausta* O.S. Osten Sacken himself (1886) noted that the two were separable only on color of the vestiture, and with the finding of intermediate specimens (Fairchild 1951, p. 441) it seems unnecessary to retain the later name.

KEY TO CENTRAL AMERICAN SPECIES OF *FIDENA*

1. Legs essentially unicolorous, either black or yellowish 4
   Legs bicolored, the femora dark, the tibiae pale 2
2. Beard white. Sides of mesonotum with a fine line of white hair from shoulder to scutellum. Abdomen black, the second to fourth tergites with small white mid-dorsal triangles; the second, fifth and sixth with white tufts on the posterior lateral angles. Wings with basal cells quite strongly infuscated ..... **gracilis** Kröb.
   Beard dark, brown to black 3
3. Abdomen reddish in ground color, entirely golden yellow haired above, except the first tergite. Thorax wholly dark haired. Wings with basal cells infuscated ..... **fulvosericea** Kröb.
   Abdomen blackish in ground color on at least the first three tergites. Second tergite with a tuft of white hairs laterally. Fourth or fifth to last segments brown or yellow in ground color, clothed with yellow, brown or orange rufous hairs. Sometimes small middorsal tufts of white hairs are present on second or third to fourth tergites ..... **rhinophora** Bell. (=*pyrausta* O. S.)
4. Legs wholly pale yellowish brown. Beard, pleura, sternum and abdomen beneath wholly pale pollinose and creamy haired. Mesonotum and abdomen above dark brown, black haired, the abdominal tergites with small median tufts of pale hairs. Wings uniformly lightly fumose, not darker basally ..... **columbiensis** Kröb.
   Legs wholly black, only the tarsi sometimes brownish 5
5. Wings hyaline or greyish fumose, the bases blackish and at least the apices of the basal cells darkened around the cross veins 6
   Wings strongly and uniformly yellowish, only the extreme bases darker 8
6. Beard black. Antennae and palpi bright orange yellow. Thorax black and black haired. Abdomen black, with sparse white hairs on sides of second and hind margins of fifth to seventh tergites ..... **schildi** Hine
   Beard white or cream colored. Abdomen extensively golden haired. Antennae and palpi blackish 7

7. Clypeus produced, as long or longer than frons. Hairs of mesonotum all dark. Apices of basal cells slightly darker than rest of wing. Second to last abdominal segments clothed with yellow or orange rufous hairs. ..... **howardi** Fchld.

   Clypeus much less produced, shorter than frons. A large conspicuous tuft of white hairs on each side of the scutellum. Basal cells, extreme base of wing and anal area quite strongly blackish. Second tergite with a median and lateral patches of yellow hair, third yellow haired with a pair of dorsolateral black haired patches, remaining tergites densely yellow haired ..... **trapidoi** n. sp.

8. Abdomen dark brown to black, shiny, mainly sparsely black haired, but with tufts of silvery white hairs on sides of second, fifth and sixth tergites. Beard black or dark brown ..... **isthmiae** Fchld.

   Abdomen pale yellowish, except black first segment, shiny, clothed entirely with rather short appressed golden hairs. Beard pale yellowish brown. ..... **bicolor** Krŏb.

Dichelacera (**Dichelacera**) **crocata** sp. nov.

Plate II, fig. 10

Female.—Length 9.5–12 mm., of wing, 10–12 mm. Eyes bare, in life green with a broad transverse median purple band and the greater part of upper half of eye purple. Frons about 2.5 times as high as basal width, distinctly narrower at vertex than at base, bright yellow pollinose. Frontal callus black, as wide as frons, with a median triangular prolongation above. Vertex with a blackish or discolored triangle bearing black hairs, the small tubercle at its apex, but without visible vestiges of ocelli. Subcallus, genae and frontoclypeus bright yellow pollinose, the last rather thinly clothed and with a tendency to become denuded and subshiny. Beard sparse, yellow. Antennae dull yellowish brown, black haired, the annulate portion and most of the apical half to two-thirds of the lower branch of the basal portion black. Palpi long and very slender, dull yellowish, mostly yellow haired, but with a few scattered black hairs. Proboscis somewhat exceeding palpi, nearly equalling head height, theca yellow, labella black, both sclerotized and shiny.

Mesonotum dark brown in ground color, the anterior half to the transverse sutures bright yellow pollinose and yellow haired. Posteriorly to this is a black pollinose and black haired transverse band between the wing bases. The remainder of the mesonotum is yellow pollinose and yellow haired, while the scutellum is again black pollinose and black haired. The interalar black band is quite narrow, not wider than the succeeding yellow area and generally markedly narrower. Wings with subepaulet without macrotrichiae, costa, subcosta and first vein setose above. Wings intense yellow, costal cell, and apical halves of cells Cu_2 and An_1 smoky brown. Dark band of wing filling apex to fork of third vein, and including apex of discal cell and apical half of fifth posterior cell, where its inner margin joins the posterior wing margin at apex of cell Cu_2. The inner margin of the band is quite even and the dark infuscation fills the whole apical and posterior margin of the wing evenly, without lighter areas. Legs yellow, yellow haired, except apices of fore tibiae, fore tarsi, and hind tibiae and tarsi, which are darker and black haired.

Abdomen dull yellowish brown in ground color, the first two or three segments paler. The abdomen is mainly densely yellow haired

and yellow pollinose, but the fore borders of the second to fifth tergites and all of the six and seventh are black haired. Or the abdomen may be described as having the first tergite wholly yellow haired, the remainder black haired, with on the second a very wide posterior yellow border covering three-fourths the width of the segment, on the third and fourth a somewhat narrower yellow border, wider in the middle and at the sides, covering about two-thirds the width of the segment, on the fifth a broad median yellow triangle reaching nearly to the anterior border of the segment, but sides of the segment black haired. Sixth and seventh tergites black haired. Beneath, the abdomen is dull yellowish brown, subshiny, clothed with short yellow hairs.

Holotype female, Almirante, Bocas del Toro Province, Panama, 19 June, 1952, Yellow Fever Station D. Taken attacking man at a platform in the trees 36 feet above ground level.

Paratypes: 37 females from same locality as holotype taken in May (2), June (8), July (3), and Dec. (2) 1951, and May (6), June (4), July (2), August (6) and September (4) 1952. Of these specimens 32 were taken at platforms in the forest canopy from 36 to 54 feet above ground level, and only 5 were taken at ground level.

This species may be distinguished from *D. regina* Fchld. by the considerably broader frons, more even wing band, and much greater proportion of yellow in the body vestiture. From *D. rex* Fchld. it can be separated by the fact that the inner margin of the wing band is never proximal to the fork of the third vein, and the body is much more extensively and brighter yellow. All three species occur together at Almirante. *D. regina* is also an arboreal species: of the 29 specimens from Almirante, 19 were taken in the forest canopy, but it is less confined to this habitat. *D. rex* has only been taken at ground level at Almirante, 20 specimens, though elsewhere an occasional specimen is taken in tree-top catches. All the specimens of *crocata* are uniform in their characters and show no tendency to intergrade with either *regina* or *rex*.

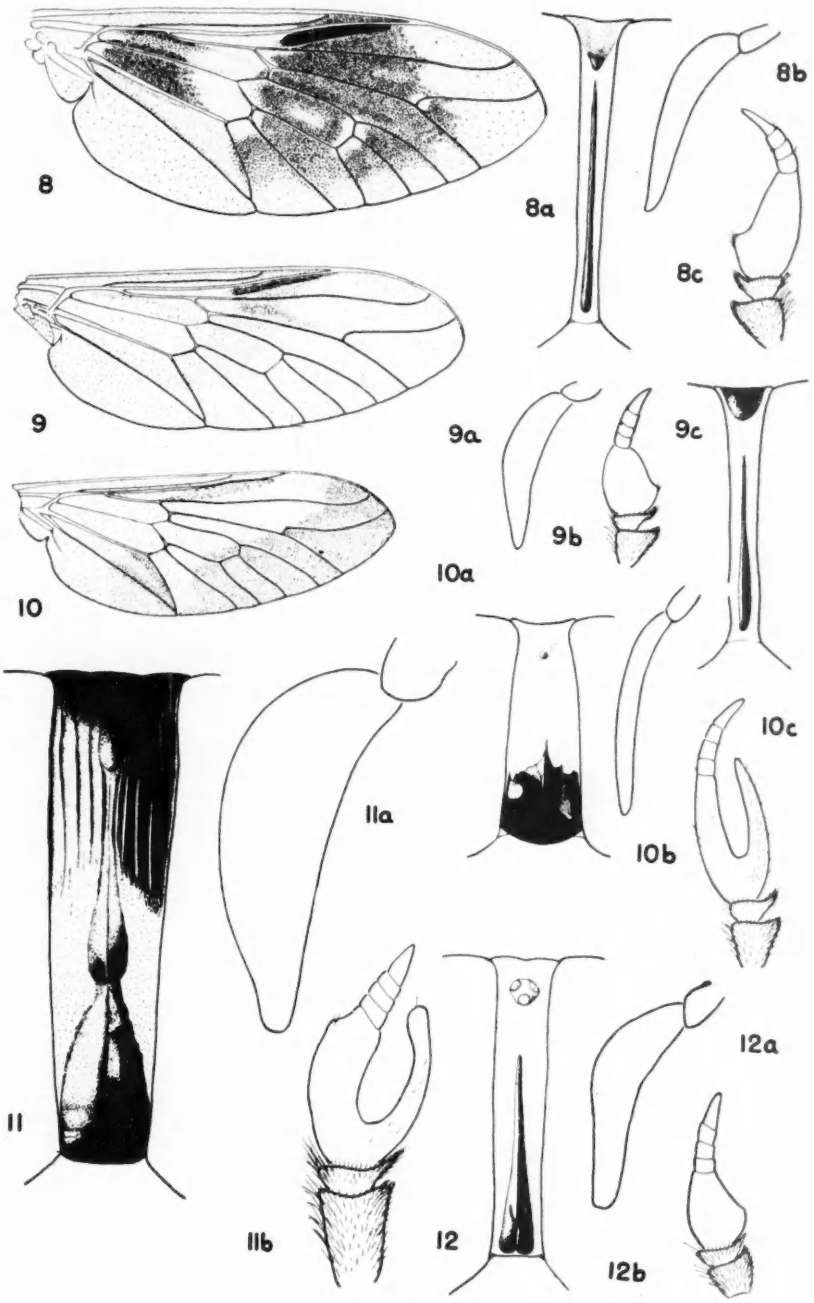
Stibasoma stilbium sp. nov.

Plate II, fig. 11

Female.—Length 19–20 mm., of wing 18.5–19.5. Eyes bare, in life dark blackish above, dull greenish below, the colors sharply separated along a line extending from the inner angle transversely across the middle of the eye, but less distinctly separated at the outer angle. Frons about 5.5 times as high as basal width, wholly black and black haired, the basal callus poorly marked, merging into a seamed and wrinkled median stripe which joins the poorly delimited vertical triangle. There is a weekly defined tubercle at vertex and vestiges of an anterior ocellus.

EXPLANATION OF PLATE II

FIG. 8, a, b, c. *Tabanus* (*Philipotabanus*) *nigrinubilus* n. sp. Holotype: wing, frons, palp and antenna. FIG. 9, a, b, c. *T.* (*Ph.*) *grassator* n. sp. Holotype: wing, palp, antenna and frons. FIG. 10, a, b, c. *Dichelacera crocata* n. sp. Holotype: wing, frons, palp and antenna. FIG. 11, a, b. *Stibasoma stilbium* n. sp. Holotype: frons, palp and antenna. FIG. 12, a, b. *Leucotabanus aurarius* n. sp. Holotype: frons, palp and antenna.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Subcallus, frontoclypeus and genae shining pearl grey pollinose, changing from whitish to nearly black with changing light incidence, the last two rather densely beset with black hairs. Beard black. Antennae black, somewhat pearly pollinose, black haired except for some silvery hairs at base of first segment above. Dorsal tooth long, reaching beyond the first annulus with a tendency for its tip to be clubbed. Palpi quite strongly inflated, black and black haired. Proboscis black, less than head height and not much exceeding palpi, the theca and labella well sclerotized, the latter shiny.

Mesonotum and scutellum black to dark brown, dark brown pollinose, densely black haired. Pleura and sternum black and rather densely black haired. Legs black, black haired, except for a small patch of silvery white hairs on outside of base of each tibia. Fore tibiae markedly swollen, hind tibiae with both an external and internal fringe of long hairs, all legs quite densely hairy. Wings with subepaulet bare, costa and first vein setose above, subcosta with a single row of macrotrichiae above, densely setose below; venation normal, no appendix on third vein, first posterior cell (R_5) somewhat narrowed. Wings black at extreme base to the arculus, the rest deeply yellowish tinged fading to faintly dusky at apex; costal cell brown, and in some specimens a tendency for the centers of the cells to be more hyaline, so that the veins appear yellowish to brownish margined.

Abdomen dark reddish brown to nearly black in ground color, the first tergite wholly black haired or with a posterior fringe of sparse yellow hairs mixed with the black. Succeeding segments clothed with dense short shiny coppery red hairs basally, bright shiny yellow hairs on the posterior margins. The proportions of red and yellow hairs varies, some specimens having the tergites mostly yellow haired. In two specimens there is some admixture of black hairs with the coppery ones, and in all the fifth to last tergites are almost wholly yellow haired and much telescoped into the preceding segments. Beneath, the first sternite is black haired, the second with some yellow at sides of posterior margins, the remainder with increasingly complete and increasingly broad yellow haired hind margins, otherwise the sternites are black haired.

Holotype female, Almirante, Bocas del Toro Province, Panama, 4 June, 1952, taken at Yellow Fever station C, 54 feet above ground level in the forest canopy.

Paratypes, 3 females, same locality as holotype, 23 May, 1951, 2 and 10 June, 1952, all taken at platforms in the forest canopy from 36 to 54 feet above ground level.

This species will run to *St. sulfurotaeniatum* Kröb. in Kröber's (1932) key to the genus. In this key the abdomen is said to have the second and third tergites shining sulfur yellow banded, but the original description (1931 p. 338) states that tergites 2 to 7 have broad pure sulfur yellow hind marginal bands. The present species differs from the original description in having the abdomen darker in ground color, with copper red hairs basally on the tergites and in lacking a prealar tuft of silver white hairs. Kröber gives no figure of his species, nor any description of the shape of the antennae, so until specimens from near the type locality (Para, Rio Acara) can be compared, it seems

better to describe the Panama material, although it may later prove but a geographical race.

Stibasoma panamensis Curran

Stibasoma theotaenia panamensis Curran, 1934. Fam. Gen. N. A. Dipt., p. 153, fig. 23 (head, no description). Fairchild, 1951, Ann. Ent. Soc. Amer., 44: 451, figs. 3, 3a, 3b.

Stibasoma theotaenia var. *panamensis* Curran. Fairchild, 1940, Ann. Ent. Soc. Amer., 33: 685–686.

I have now had the opportunity of examining specimens of true *theotaenia* from Sao Paulo, Brasil and find that it differs very considerably from Panama specimens. Aside from the color of the vestiture of the abdomen, the color of the integument of the abdomen in *theotaenia* is black, orange yellow in *panamensis*. *Theotaenia* also has much stouter palpi, a pollinose subcallus, and the third antennal segment has a long arched dorsal spine reaching to the third annulus, much as in *St. fulvohirtum* Wied. *Panamensis* thus is a distinct and not very closely allied species. Whether the Venezuelan specimens mentioned by Schiner are the same is uncertain.

Seven females from Almirante, Bocas del Toro Province, Panama, taken in January (1), May (1), June (1), July (3) and September (1), all collected at platforms in the tree-tops from 36 to 54 feet above ground level.

The comparative scarcity of flies of the Genus *Stibasoma* in collections may be due to the predominantly arboreal habitats which many of them seem to prefer. Of the species occurring in Panama all except *chionostigma* O.S. are predominantly arboreal, and that species has not been taken at all since tree-top collections were initiated. Thus of the 59 specimens of *fulvohirtum* at hand from various localities in Panama, all but 3 were taken at platforms in the forest canopy. A single specimen from Wachope, Limon Prov., Costa Rica, 9 Aug. 1951 extends the range of the species somewhat. Of the 7 specimens of *St. apicimacula* Fchld. now known, 5 were taken at forest canopy platforms. Of the 12 specimens of *St. panamensis* known to me the above 7 and possibly one other were taken in the tree-tops, and all the known specimens of *St. stilbium* n. sp. came from tree-top collections.

A key to the known Central American species in given below, omitting *venenatus* O.S. which belongs in *Rhabdotylus* Lutz.

KEY TO CENTRAL AMERICAN SPECIES OF *STIBASOMA*

1. Wings almost wholly black with purple reflections. Subcallus shiny. Abdomen with first two tergites bright yellow haired, the remainder copper red haired. (Panama) ..... **panamensis** Curr.
   Wings not wholly black, with at least a large light area below the stigma. Abdomen not so marked 2
2. Wings with an extensive black pattern or a black subapical patch. Subcallus at least shiny in the middle 3
   Wings yellowish or greyish subhyaline, not contrastingly marked. Subcallus silvery grey pollinose 4
3. Wings black or dark brown with the apex and a large patch from stigma to discal cell yellowish hyaline. Frons largely pollinose. Abdomen largely reddish brown, black haired. (Mexico to Colombia). ..... **chionostigma** O. S.
   Wings largely hyaline, yellowish along costa and with a blackish patch in apex of marginal and first submarginal cells. Frons largely black and denuded. Abdomen black with narrow yellow bands on hind margins of tergites 1 and 2. (Panama) ..... **apicimacula** Fchld.

4. Large species, usually over 19 mm. Thorax wholly black; abdominal tergites coppery haired basally, yellow haired on the margin. Legs including tarsi predominantly black. (Panama).....**stilbium** n. sp.
Smaller, 15 mm. or less. Thorax with at least some rufous orange hair or white hair tufts at sides; abdominal tergites black with narrow yellowish posterior margins. Legs extensively white marked, the tarsi and mid-tibiae yellowish. (Northern Brazil to Costa Rica).....**fulvohirtum** Wied.

Stenotabanus (Aegialomyia) geijskesi sp. nov.

Plate I, fig. 7

Female.—Length 11 mm., of wing 8.5 mm. Eyes bare, the sketch accompanying the specimen showing a single broad median transverse stripe not reaching the outer margin and the lower margin stippled, labelled "lower indistinct"; presumably the eyes were greenish, the band purple or dark reddish and the lower margin broadly greenish-purple. Frons broad, about 2.7 times as high as basal width, yellowish grey pollinose. Basal callus as wide as frons, dark brown, protuberant, extended above to an indistinct median callus. Vertex with a large round shiny brown boss but without any vestiges of ocelli. Subcallus, fronto-clypeus and genae pale grey pollinose, the first slightly tinged with yellowish, the last with sparse white hairs. Antennae pale yellowish brown, black haired, the third segment rather broad and with a well marked angle above. Palpi stout, curved and inflated, white and white pollinose beset with mixed black and white hairs. Proboscis brown, hardly longer than palpi, labella large and membranous.

Mesonotum light brown, obscurely striped, light greyish brown pollinose and beset with sparse black and white hairs. Scutellum concolorous. Pleura and sternum pale grey pollinose, sparsely white haired. Wings with subepaulet bare, costa, subcosta and first vein setose above, venation normal, a short appendix on upper branch of third vein, stigma pale yellow, wings entirely hyaline. Legs pale brown, the femora mostly pale haired, the tibiae and tarsi with mostly dark hairs. Fore tibiae dusky at apex and the fore tarsi darker than the others.

Abdomen pale brown in ground color, the pollinosity of two shades of brown forming the following pattern. First tergite pale at base and narrowly so on hind margin, between the two a narrow band of darker brown parallel to hind margin. Second to sixth tergites with a pale hind margin, obscure pale median triangles which reach the anterior margin, and a large round dorsolateral spot on each side separated from both anterior and posterior margins. Seventh tergite pale at apex. Otherwise the abdomen is a darker brown. The pale areas are beset with pale yellowish white hairs, the dark areas with dark reddish brown to black hairs. Beneath, the abdomen is entirely pale pollinose, sparsely pale haired.

Holotype female, Matappica strand, Suriname, 20 Oct., 1940, Geijskes coll. In the collection of Dr. C. B. Philip.

This species is close to *littoreus* Hine, from which it differs in differently proportioned frons, broader and more angled third antennal segment, blunter and stouter palpi and in lacking the well marked middorsal abdominal stripe of *littoreus*.

Stenotabanus (Aegialomyia) blantoni sp. nov.
Plate I, fig. 5

Female.—Length 8–9 mm., of wing 7.5–8 mm. Eyes bare, in life purple with two broad green bands, the lower of which crosses the middle of the eye from the angle of the frons and face to the outer margin. The upper purple area at the occipital margin is somewhat dilute and suffused with greenish. Or the eye may be described as green with the upper and lower margins purple and a narrow transverse purple band above the middle. Frons very broad, about twice as high as basal width, yellowish grey pollinose. Frontal callus black, very protuberant, as wide as frons, prolonged above to a vestigial median callus. Vertex dusky yellowish, shiny the full width of frons but without swelling, tubercle or vestiges of ocelli. Subcallus and upper angles of genae yellowish grey pollinose, frontoclypeus and genae below level of antennae steel grey. Beard rather sparse, whitish. Antennae dull yellowish, the setae black. Third antennal segment without prominent angle above, the style about as long as the basal plate. Palpi whitish, pale pollinose with long white hairs on first and base of second segment, shorter appressed black hairs on remainder, rather inflated basally but with slender apices. Proboscis short, hardly exceeding the palpi, brown, the labella large and membranous.

Mesonotum and scutellum dark brown, greyish brown pollinose, very faintly striped, beset with rather sparse shiny pale hairs. Pleura and sternum pale brownish grey pollinose, beset with long sparse whitish hairs. Wings with venation normal, subepaulet bare, costa, subcosta and first vein setose above; hyaline, the veins very narrowly and faintly brown margined, the upper fork of third vein with a moderate to rather long appendix, stigma narrow, yellow. Legs dusky yellowish brown, the femora pale haired, the tibiae and tarsi dark haired, fore tibiae somewhat darkened distally.

Abdomen dark brown with a pattern of pale brownish grey and dark brown pollinosity. First tergite pale on anterior and lateral borders, dark in the middle and with a pale hind border. Second to fifth or sixth tergites with pale hind and lateral borders, pale narrow median triangles which may or may not quite reach the fore border, and pale, somewhat rectangular dorsolateral spots which are joined to the hind marginal pale band on the second tergite, but may be more or less clearly separated from it on the succeeding segments. Seventh tergite dark, obscurely pale margined behind. Beneath, the abdomen is wholly pale greyish pollinose and pale haired.

Holotype female, Jaque, Darien Prov., Panama, 26 July, 1952, in mosquito light trap. F. S. Blanton leg.

Paratypes, 2 females, same locality, 24 and 25 July, 1952.

This species seems rather closely related to *geijskesi* n. sp., *littoreus* Hine, *paitillensis* Fchld., and a number of other small coastal marsh or beach inhabiting species. It is the second of this group to be taken on the Pacific coast of Panama and differs from *paitillensis* in larger size, broader frons, more denuded vertex, and in having but two green bands on the eye. Named in honor of Lt. Col. F. S. Blanton, M. S. C., whose enthusiastic collecting of biting Diptera is very materially increasing our knowledge of the Panama fauna.

Stenotabanus (Aegialomyia) littoreus Hine

Plate I, fig. 6

Tabanus littoreus Hine, 1907, Ohio Nat., 8(2): 227–228 (♀, ♂; Puerto Barrios, Guatemala). Surcouf, 1921, Genera Insect, Tab., p. 73. Bequaert, 1925, 13th Ann. Rep. Med. Dept. United Fruit Co., p. 206 (Puerto Cortez, Honduras); 1931, J. New York Ent. Soc., 39: 543 (Northern Quintana Roo, Mexico); 1938, Carnegie Inst. Washington, Pub. No. 499, p. 226 (Puerto Barrios, at light). Kröber, 1934, Rev. Ent., 4(3): 300.

A single female of what I believe to be this species was taken biting man on the beach near Pina, Colon Prov., Panama, 12 Nov., 1950. This specimen was compared with specimens determined by Dr. Bequaert as *littoreus* and with notes taken on Hine's types by me in 1940. My specimen agrees very well with Hine's description, except that the median abdominal stripe is better defined than he indicates. The subepaulet is bare, costa and first vein setose above, subcosta setose below but apparently bare above. Since the species of this group are all very similar in color and markings, a figure of frons, antennae and palpus is here included. The eye pattern of this specimen was not recorded in life but enough remains to indicate two broad light bands on a dark ground, as figured by Bequaert (*l.c.* 1931).

Stenotabanus (Stenotabanus) fulvistriatus (Hine)

Tabanus fulvistriatus Hine, 1912, Ohio Nat., 12(7): 515 (♀; Chiapas, Mexico). Surcouf, 1921, Gen. Insect., Tab., p. 69. Kröber, 1934, Rev. Ent., 4(3): 309.
Tabanus unistriatus Dunn, 1934, Psyche, 41(3): 174 (in part; Panama).
Stenotabanus (Stenotabanus) fulvistriatus Fairchild, 1942, Ann. Ent. Soc. Amer., 35(3): 303, fig. 11 (♀; Panama, Costa Rica).

Specimens of both sexes from Costa Rica (Palmar, Puntarenas Prov., P. & D. Allen, no date) and from Dampf's collection through Dr. Philip (labelled M.F. 4321 and M.F. 4238, presumably Mexico) enables the male to be described, while female specimens from Guatemala (San Juan, Sinacapa, Esquintla, 13 June, 1950, J. M. Brennan; Antigua, no date, J. R. de Leon; Yepocapa, Chimaltenango, 26 Dec., 1949, H. Dalmat) and Nicaragua (Rio Majase, Cañas Gordas, N. of Rivas, probably July, 1952, J. Boshell) fill the gap in distribution between Panama and Mexico. The species has been taken in Panama so far only on the Pacific side in Chiriqui Province, near the Costa Rican border.

Male.—Length 9–10 mm., of wing 7.5–8 mm. Head enlarged, eyes holoptic, bare, the area of enlarged facets extensive, about three-fourths of total eye area, the two types of facets very clearly demarcated and differentiated. Vertical tubercle present and well developed, not deeply sunk between eyes. Frontal triangle yellow pollinose with a brown transverse pollinose stripe at the level of the junction of the two types of eye facets and another brown band at level of antennae. Palpi orange yellow, inflated, the tip attenuated and turned down, clothed with long golden hair and yellow pollen. Thorax and legs as in female, wing as in female though more dilute brownish. Abdomen slender and pointed, orange yellow pollinose, the median stripe defined only by having yellow hairs while the sides have black hairs. In the female the stripe is pale yellow pollinose, the sides dark brown pollinose and hence much more distinct.

Neoallotype male, Palmar, Dept. Puntarenas, Costa Rica, no date, P. and D. Allen coll.

Stenotabanus atopus sp. nov.

Plate I, fig. 3

Female.—Length 12.5–14 mm., of wing 11–12 mm. Eyes bare, green in life, no bands or other pattern. Frons about six times as high as basal width, widest at vertex, dull orange yellow pollinose with sparse black hairs. Basal callus yellow, narrower than frons, gradually narrowed into a ridge or keel which reaches about two-thirds the distance to vertex. No tubercle or denuded area at vertex, nor any vestiges of ocelli. Subcallus slightly inflated, bare and shiny, yellow. Frontoclypeus and genae light yellowish brown pollinose; beard sparse, yellowish. Antennae orange brown, the first two segments black haired, the third quite wide with a prominent dorsal angle. Annulate portion of third segment a little darker than basal portion. Palpi orange brown, dark grey pollinose, beset with mostly black hairs, but a scattered few yellow hairs towards base. Proboscis less than head height, not greatly exceeding palpi in length, brown, the labella largely pollinose with only a small strip of shiny sclerotization. Theca short, pollinose.

Mesonotum blackish brown in ground color, clothed with yellowish grey pollinosity, more yellowish anteriorly, in the suture and on scutellum, the whole beset with short black hairs and longer yellow hairs around the margins and anteriorly. Pleura and sternum lighter yellowish grey, beset with long golden yellow hairs. Fore legs blackish brown, bases of tibiae a little lighter, all black haired except the pale pollinose and yellow haired coxae. Mid-legs dusky yellowish brown, the tibiae and tarsi darker, femora with considerable yellow hair posteriorly, tibiae and tarsi black haired. Hind legs with paler femora with much yellow hair, tibiae and tarsi blackish and black haired. Subepaulet bare, pointed; costa, subcosta and first vein setose above; a long to very long appendix on upper branch of third vein. Wings yellowish basally, especially the costal cell, the area beyond stigma distinctly smoky. In some specimens the veins are faintly brown margined with suggestions of clouds around the cross veins.

Abdomen light yellowish to dirty greyish brown in ground color, very thinly brownish pollinose, clothed with moderately dense short black hairs. There is a quite broad and rather even yellow haired middorsal stripe from the first to fifth or sixth tergite and the integument beneath this stripe is more thickly and paler yellow pollinose. The sides of all tergites except the last one or two are also yellow haired. Beneath, the sternites are subshiny, thinly clothed with short yellow hairs.

Holotype female. Almirante, Bocas del Toro Province, Panama, 5 July, 1951. Taken in a Shannon trap at Yellow Fever station B, ground level.

Paratypes, 3 females, same locality as holotype, 5 June, 12 July and 22 August, 1951, all taken in a Shannon trap at ground level.

This species is obviously and closely related to what I have been calling *Cryptotylus luteoflavus* Bell., the structure of head, antennae

and wing venation being almost identical. Its discovery confirms certain doubts which I have entertained for some time as to the placement of *luteoflavus* in *Cryptotylus*. The two species differ from *Cryptotylus* in lacking the developed antennal tooth, in relatively unsclerotized labella, in well developed frontal callus and shiny subcallus and in having the male eye facets, at least in *luteoflavus* but slightly differentiated. They do not fit well into current interpretations of *Stenotabanus* either, lacking the enlarged eye facets in the male and being larger and with broader antennae than most species placed therein. However, the bare subepaulets rule them out of *Tabanus* and as *Stenotabanus* is currently somewhat of a catch-all for *Tabanus*-like species with bare subepaulet and no other obvious characteristics, they may as well be placed here for the time being, although I refrain from placing them in any specific subgenus.

I am inclined to suspect that the small, relatively unspecialized species of *Stenotabanus* may represent the stock from which a good many of the more specialized groups of Neotropical *Tabaninae* originated Such genera as *Diachlorus*, *Leptapha* and even *Dichelacera* in the broadest sense contain species which are quite *Stenotabanus*-like. The Neotropical *Tabaninae* are an exceedingly diversified group, but the bulk of the odd and specialized forms have the subepaulet bare, and I believe are ultimately derivable from simpler forms like *Stenotabanus*. The more typically *Tabanus*-like forms, with setose subepaulet, have been derived I believe, at least in part, from more recent Nearctic immigrants. It is of interest in this connection to note that the majority of the more strictly Neotropical elements are confined to a forest environment, while the forms showing Nearctic affinities tend to be more widespread and to be dominant in open and cultivated areas. The position of the Chilean-Patagonian forms, *Dasybasis* and allies, seems rather different, and they do not appear to have played any important role in the development of the Neotropical fauna as a whole. As Mackerras and Fuller (1942 p. 42) have shown for Australia, the more strictly Antartic groups, such as *Dasybasis* and *Pelecorhynchus* tend to be confined to the cooler areas in the south of that continent, extending north mainly along the eastern highlands. The Chilean-Patagonian elements in South America are rather similar structurally, several genera being common to both continents, and they also seem to extend into the geographic tropics only along the cool Andean chain. The ultimate origin of the more strictly Neotropical fauna is, of course, highly speculative, but I believe the available evidence suggests derivation from some unspecialized Antarctic group rather than from any existing Nearctic stock. Such a form as *Scaptiodes* shows many of the characters one would expect in such a stem-form, bare subepaulet, unmodified proboscis and antennae, hairy eyes and a well developed verticle tubercle with vestiges of ocelli. Except for the hairy eyes, it could fit fairly well into *Stenotabanus*. Incidentally, the marked tendency for species from cold climates, due either to high altitude or high latitude, to have hairy eyes seems to me more than coincidence, and I doubt if it is as fundamental a character as has been believed, at least in the *Tabanidae*.

Stenotabanus pompholyx sp. nov.

Plate I, fig. 4

Female.—Length 12 mm., of wing 10 mm. Eyes bare, the pattern (revived) consisting apparently of two narrow green bands separated by a narrow purple band, the rest of the eye being purple. Frons broad, a little over three times as high as basal width, clothed with yellowish grey pollinosity and with a diffuse, broad, transverse band of dark brown pollinosity between basal callus and vertex. Basal callus as wide as frons, black, shiny and protuberant, like a bubble of tar, extended above on each side and in the middle by a slender short raised line. Vertex with a raised rounded triangular area which is black and shiny, but without vestiges of ocelli. Subcallus light yellowish pollinose, pale grey on genae and frontoclypeus. At the level of the antennae a transverse band of darker, dusky pollinosity separates the two colors. Beard whitish. Antennae dusky yellowish, black haired, the annulate portion black except for extreme tip, which is yellow. Palpi yellowish, pale pollinose, with short black hairs and longer white hairs, the latter mostly at base. Proboscis blackish, short, the labella membranous.

Mesonotum dark brown, subshiny, very obscurely striped, sparsely clothed with short shiny silvery or brassy hairs. Scutellum dark at base, reddish at apex, also sparsely pale haired. Pleura and sternum steel grey, sparsely white haired. Subepaulet bare, costa, subcosta and first vein setose above and a short appendix on upper branch of third vein. Wings hyaline, the costal cell very faintly yellowish, stigma yellow and rather weak brownish clouds around all cross veins, fork of third vein and anterior border of wing from stigma to apex. Legs brown, the femora mainly pale haired, the tibiae and tarsi black haired. Fore tibiae a little darker apically. Abdomen subshiny, perhaps somewhat rubbed, blackish in ground color, but the first two segments extensively or largely reddish, especially at sides, and remaining segments with decreasingly distinct diffuse reddish dorsolateral patches. The hind margins of all tergites are narrowly paler, especially marked on the second, where there are indications of a pale pollinose median triangle. The tergites are clothed with black hair except for pale haired lateral margins and a mid-dorsal row of rather diffuse contiguous pale-haired triangles on first to fifth tergites and a few pale hairs in middle of sixth tergite. Beneath, the abdomen is dark in ground color, pale pollinose and pale haired.

Holotype female, Patiño airfield, Patiño Point, Darien, Panama, 15 July, 1952, F. S. Blanton leg. Taken in a mosquito light trap.

Paratype, one female, same locality as holotype, but 18 July, 1952, in a light trap. The specimen lacks the abdomen and posterior legs, but agrees perfectly in head structures, wing color, etc.

This species is one of those indefinite forms which make the generic classification of the Tabanidae so difficult. In general fascies, body color, presence of a shiny boss at vertex and a wide protuberant basal callus the species resembles closely some of the Andean species placed by others in *Dasybasis* (= *Agelanius*) or *Hybomitra* (= *Therioplectes*), except that the eyes are wholly bare. The bare subepaulet rules it

out of *Tabanus* and *Hybomitra*, though some species of *Dasybasis* appear to have nearly bare eyes. In other respects it is not dissimilar to *Aegialomyia*, though the frons is narrow and callus more protuberant and the color and general appearance rather different. For the present it seems best to leave it in *Stenotabanus* on account of the bare subepaulets and lack of any other marked characteristics.

Leucotabanus aurarius sp. nov.

Plate II, fig. 12

Female.—Length 12 mm., of wing 10 mm. Frons about 5.5 times as high as basal width, dark brownish grey pollinose. Callus a little over half as wide as frons below, evenly tapering to a blunt point two-thirds the distance to the vertex, black, as figured. Vertical tubercle prominent, with well marked vestiges of ocelli. Subcallus subshiny, probably secondarily denuded, the sides, frontoclypeus and genae very dark yellowish grey pollinose. Scattered black hairs are present below the antennae and the beard is jet black. Eyes bare, probably unicolorous blackish in life. Antennae wholly light orange brown, the basal segments black haired, as figured. Palpi moderately stout, black and black haired, as figured. Proboscis a little longer than palpi, the labella large and membranous.

Mesonotum blackish brown, clothed in the center with rather dense, short, black hairs; the anterior margin including the humeri, a narrow strip above the wing insertions and the scutellum clothed with longer dark golden hairs, the line of demarkation between the colors very sharp. Pleura and sternum black, thinly dark greyish pollinose and sparsely black haired. Legs wholly black and black haired. Wings hyaline, the costal cell and to a less extent the basal two-thirds of the wing dilute yellowish. Stigma yellow. Subepaulet, costa, subcosta and first vein with macrotrichiae; no appendix on upper branch of third vein.

Abdomen above black and black haired, the second tergite with a patch of white hairs at the sides, the fourth tergite with a narrow posterior border of white hairs, slightly widened in the middle. Beneath, the first sternite bears a small median patch of white hairs, the second is wholly white haired and the fourth bears a narrow white haired hind margin; otherwise the venter is black and black haired.

Holotype female, Almirante, Bocas del Toro Province, Panama, 5 July, 1951, taken in a Shannon trap during the day at Yellow Fever Station B. Quiñones coll.

With the addition of the above species, the genus *Leucotabanus* now includes 15 species, so that a new key to the known forms to replace that published eleven years ago (Fairchild 1941) seems in order.

KEY TO SPECIES OF *LEUCOTABANUS*

1. Thorax clothed wholly or partly with yellow, orange or yellowish grey tomentum; legs entirely black or brown, not bicolored 2
   Thorax not yellow, generally with more or less white tomentum; legs not entirely dark, the tibiae more or less white 4
2. Mesonotum wholly rich lemon yellow. Abdomen above, legs, and palpi entirely jet black. Subcallus bare and shiny. (Costa Rica to Brasil), ... **flavinotum** Krŏb.
   Mesonotum not wholly lemon yellow. Abdomen above with second and fourth tergites with at least some white or yellowish hairs 3

3. Mesonotum black haired on the disc, orange haired on the margins and scutellum. Second tergite with lateral white haired patches, fourth with a narrow transverse white haired band. (Panama) . . . . . **aurarius** n. sp.
Mesonotum grey or yellowish grey. Second and fourth tergites with yellowish or white transverse bands. Subcallus pollinose. (Mexico), ... **itzarum** Beq.
4. Palpi black or nearly so, black haired 5
Palpi pale, yellowish or brownish, black or pale haired 6
5. Thorax dark to light grey on the disc, unstriped, the sides and scutellum prominently white haired. At least the second and fourth abdominal tergites, and often the third, fifth and sixth with narrow white hind margins, which may be incomplete. Stigma blackish, narrow. (Mexico to Paraguay) . . . . . **leucaspis** Wied.
Thorax with a median and sublateral white stripes; pleura and scutellum white haired, second and fourth abdominal tergites rather broadly white. Stigma black, unusually broad and prominent. (Brasil). . . . . **sebastianus** Fchld.
6. Antennae black 7
Antennae brown or yellowish 10
7. Small species, less than 10 mm. long. Mesonotum unstriped, blackish, the sides and scutellum white haired. Abdomen black, with all tergites pale margined behind, but only the first, second and fourth with white hairs. (Brasil) . . . . . **pauculus** Fchld.
Larger species, over 13 mm. Mesonotum prominently striped 8
8. Mesonotum dark chocolate brown, black haired and with a median and two dorsolateral white haired stripes, obsolete posteriorly and tending to coalesce. Sides of thorax and scutellum white haired. Abdomen chocolate brown, black haired; first tergite with white hairs laterally, second with a median triangular and extensive lateral white haired patches and fourth with a complete white hind marginal band, widened in the middle and covering about two-thirds of the tergite. Beneath, the second and fourth sternites bear white hind margins. (Mexico to Colombia) . . . . . **canithorax** Fchld.
Mesonotum with four white stripes. Abdomen otherwise marked 9
9. Frontal callus hardly more than a slender line with a small oval enlargement below. Second and fourth tergites with complete white transverse hind marginal bands, very broad on the fourth, third with a little white hair posteriorly. Venter dark haired, only the second and fourth sternites white haired. (Southwestern U. S.) . . . . . **ambiguus** Stone
Frontal callus more than half as wide as frons below, gradually tapering towards vertex. First tergite white haired at sides, second with a broad middorsal triangle and lateral white patches, fourth with a broad continuous band, third, fifth and sixth with small mid-dorsal triangles and lateral white patches. Sternites wholly pale haired. (Ecuador, Peru) . . . . . **weyrauchi** Fchld.
10. Subcallus denuded, shiny. Frons rather broad, the frontal callus an inverted "T." Whole insect light brown, the thorax white haired and all abdominal tergites with white haired hind margins. (Bolivia), ... **pallidus** Kröb.
Subcallus pollinose 11
11. Frontal callus well developed, nearly as wide as, or nearly filling whole frons. All tergites extensively white haired 12
Frontal callus narrowly drop-shaped to ridgelike. Abdomen not so marked 13
12. Frontal callus reaching about half-way to vertex, appreciably narrower than frons. Thorax pale brown, white pollinose and white haired, obscurely striped. All tergites broadly white haired behind, the first two nearly wholly white, the remainder with broad white haired triangles. (Argentina to Brasil) . . . . . **albibasis** Brethes
Frontal callus filling most of frons, reaching nearly to vertex. Coloration about as in *albibasis*. (Brasil) . . . . . **leucogaster** Fchld.
13. Small 10–12 mm., pale brown species, the thorax white haired, the abdomen with all tergites white margined. (Southern U. S.) . . **annulatus** Say
Larger, 14–16 mm., the abdomen otherwise marked 14

14. Whole insect black in ground color. Annulate portion of third antennal segment as long or longer than basal portion. Thorax uniformly grey. Abdomen with all tergites white margined, but the second and fourth with much broader bands than the others. Legs prominently bicolored. (Mexico, Guatemala) ..... **nigriventris** Kröb.

Whole insect light to dark chocolate brown. Annulate portion of third antennal segment shorter than basal portion. Thorax distinctly striped. Abdomen with second and fourth tergites broadly white behind, the band expanded into a mid-dorsal triangle; first tergite dark, third, fifth and succeeding tergites with a white mid-dorsal triangle and with or without a narrow white hind margin. Legs obscurely bicolored. (Br. Guiana, Brasil) ..... **leuconotum** Fchld.

Subgenus **Philipotabanus** Fchld.

Very considerable additional material in this group has not helped greatly in clarifying the rather confusing situation outlined previously (Fairchild 1942), but recent type comparisons have settled the status of two heretofore doubtful names.

Tabanus (Philipotabanus) caliginosus Bell.

Tabanus caliginosus Bellardi, 1859, Saggio Ditt. Mess. Pt. I, p. 68, Tab. II, fig. 10 (♀: Mexico).

Phaetobanus intermedius Kröber, 1930, Zool. Anz., 90(3–4): 81 (♀; Suiza de Turrialba, Costa Rica).

Tabanus (Phaeotabanus) pallidetinctus Kröber, 1930, Zool. Anz., 86: 297–298, fig. 19, 19a (Chiriquicito, Panama); 1934, Rev. Ent., 4(3): 305.

Tabanus (Phaeotabanus) medius Kröber, 1934, Rev. Ent., 4(3): 305.

Tabanus (Philipotabanus) medius Fairchild, 1942, Ann. Ent. Soc. Amer., 35(4): 458–459, fig. 16 (♀; Panama).

Dr. J. Bequaert was able recently to examine the types of Bellardi's Tabanidae in the Zoological Museum of the University of Turin and to compare specimens from Panama sent him by Dr. C. B. Philip. He found that specimens of *T. (P.) medius* Kröber determined by me, corresponded exactly with the types of *T. caliginosus* Bell., so that if my determination was correct, the species will take Bellardi's name. Among specimens of several species sent recently to the British Museum, Mr. Oldroyd found that a specimen of *caliginosus* from Almirante agrees very closely with the Type of *pallidetinctus* Kröber, and that this specimen was labelled "perhaps *T. caliginosus* Bell." by Kröber.

Aside from the material discussed in 1942, I now have a considerable series from near Almirante, Bocas del Toro Province which agrees with those previously reported. The species is quite variable in body color, specimens from Almirante ranging from rather light yellowish brown to dark cinnamon brown. The abdominal tergites seem always to be pale margined behind and in unrubbed material there is usually a more or less distinct triangle of pale hairs at least on the second to fourth tergites. A male and female from Esquinas, Golfito, Costa Rica and females from Palo Santo, Sta. Clara and Boquete in Chiriqui Province are considerably darker, nearly black, with slightly broader frons and a tendency for the pale triangles of the abdomen to be limited to the third and fourth tergites, or even the fourth only, where it is much enlarged. A single specimen from Sta. Fe, Veraguas Province, 23 May, 1950, is quite black, the frons even broader and the wing markings rather different, the clear areas around the distal end of the discal

cell and at the fork of the third vein being quite large and sharp, while there is an unusually dark brownish infuscation of the hind margin and apex of the wing. The triangles on third and fourth tergite are silvery white haired and the frons is the broadest of any specimens of this group so far seen. This last specimen was taken in company with another black species, described below, in which the same basic wing pattern is developed in the opposite direction towards reduction of the clear areas, and the frons is exceedingly narrow. Although quite different appearing from *caliginosus* from Almirante and the Canal Zone area, this specimen from Sta. Fe is connected by the Chiriqui specimens, and I believe it to be but an extreme development.

Three males of this species have been examined, from El Valle, Cocle Province Panama, 1948 (2), and Golfito, Puntarenas Province, Costa Rica, no date. They are like the females in coloration and wing pattern and easily associated with them. The eyes are holoptic, bare, the large facets well differentiated and demarkated from the small facets and occupying somewhat over half the total eye area. There is no vertical tubercle. The palpi are erect, carried close to the fronto-clypeus, the terminal segment cylindrical, acutely pointed and bearing long erect hairs. The proboscis is slender, especially the theca of the labellum, less than head height, the labella less than half total length of proboscis, and without shiny plates. The subepaulet is more sparsely setose than the adjoining costa, as is also often the case in the females.

Tabanus (Philipotabanus) elviae Fchld.

1942, Ann. Ent. Soc. Amer., 35(4): 460, fig. 12 (♀; Buena Vista, Chiriqui, Panama).

A single additional specimen from Almirante, Bocas del Toro Province, Panama, 28 June, 1951, agrees perfectly with the type in the reduced wing pattern, long antennal tooth and body color.

Tabanus (Philipotabanus) pterographicus Fchld.

1942, Ann. Ent. Soc. Amer., 35(4): 459, fig. 15.

One female from Albrook Field, Canal Zone, 8 Dec., 1949 in horse baited mosquito trap, and 8 females from Almirante, Bocas del Toro Province. The latter were taken 7 July, 1951 (1), 18 Aug., 1944 (1), 16 Oct., 1951 (4), and 13 Nov., 1951, the last at a platform in the tree tops, the others at ground level, mostly in a Shannon trap. The species is taken in company with *caliginosus* but appears to be more abundant later in the season than that species, though there are too few specimens to be very significant.

Tabanus (Philipotabanus) chrysothrix Fchld.

1942, Ann. Ent. Soc. Amer., 35(4): 459–460, fig. 17.

Two females, El Valle, Cocle Prov., 26 April, 1952 and 16 May, 1948 are like the type in being very pale with pale reduced wing picture. Five additional females, Cerro Jefe, Panama Province, 20 May, 1946 taken at light, are a little darker. Both series have the very narrow frons and relatively broad third antennal segment which serves to separate the species from *pterographicus*.

Tabanus (Philipotabanus) keenani Fchld.

1946, Ann. Ent. Soc. Amer., 39(4): 547, fig. 2; 1951, Ann. Ent. Soc. Amer., 44(3): 455.

An additional female, Mojinga Swamp, nr. Ft. Sherman, C. Z., 27 Nov., 1951 in light trap and a male, Rio Suarez, Santander, Colombia, 900 m. alt., 11–28 Aug., 1946, L. Richter coll. The last is in the collection of Dr. C. B. Philip, to whom I am indebted for the privilege of describing it, and may be designated as *Neoallotype*. The area of enlarged eye facets occupy about one-half the eye area and the large facets are well differentiated and demarkated from the small facets. Antennae yellow, more slender than in female. Thorax and abdomen dingy brownish, lighter than in female. Fourth tergite with a dorsal triangle of silvery hairs, otherwise abdomen black haired above. Wings as in female, the dark markings a little paler and a little less extensive than in female.

Tabanus (Philipotabanus) magnificus Kröber

Tabanus (Phaeotabanus) formosus Kröber, 1930, Zool. Anz., 86(11–12): 299, figs. 21, 21a (♀; Costa Rica, Colombia, Ecuador, Santo Domingo). Bequaert, 1940, Rev. Ent., 11(1–2): 291.

Tabanus (Phaeotabanus) magnificus Kröber, 1934, Rev. Ent., 4(3): 305.

Tabanus (Philipotabanus) magnificus Fairchild, 1942, Ann. Ent. Soc. Amer., 35(4): 456–458, fig. 13 (Guatemala, Costa Rica, Panama, Ecuador); 1946, Ann. Ent. Soc. Amer., 39(3): 574.

I have now seen specimens of this species from the provinces of Darien, Panama, Colon, Bocas del Toro, Veraguas and Cocle, as well as the Canal Zone. Specimens from Ecuador, from several localities in the Choco area of Colombia, Golfito, Costa Rica, and San Luis, Peten, Guatemala have also been studied. Night catches made from 6 to 9 p.m. in an area of heavy forest near Almirante, Bocas del Toro Province, show the species to be on the wing at night, and it is much more abundant in these night catches than in the day catches made at the same place. It is also taken with fair frequency at platforms in the forest canopy, and is the commonest species taken in light traps. The latter have yielded a series of six males, taken at Mojinga Swamp, nr. Ft. Sherman, C.Z., 20–21 May, 1952, and since this sex is undescribed a description is here included.

Male.—Head enlarged, eyes bare, holoptic, the large facets occupying fully two-thirds eye area, strongly differentiated from the small facets, but the line of demarkation between the two types not sharp. Vertical tubercle a slender process deeply sunk between the eyes. Subepaulet setose. Palpi porrect, inflated. Proboscis more slender than in female, the labella small, without shiny plates. Antennae as in female, but the median triangles on abdomen less evident.

Neoallotype male, Mojinga swamp, nr. Ft. Sherman, C. Z., 21 May, 1952, in mosquito light trap, F. S. Blanton coll. Five additional males from the same locality, 20 and 21 May, 1952; one male Almirante, Bocas del Toro, Panama, 30 May, 1951 and one male Esquinas, nr. Golfito, Puntarenas Dept., Costa Rica, P. & D. Allen, no date.

Tabanus (Philipotabanus) grassator sp. nov.

Plate II, fig. 9

Female.—Length 9.5 mm., of wing 10.5 mm. Eyes bare, dull bronzy in life. Frons dark grey pollinose, about 7.5 times as high as

basal width, as figured. Callus slender, club shaped, brown below, blackish above. Vertex shiny, slightly raised, but no true tubercle nor any vestiges of ocelli. Subcallus and fronto clypeus yellowish brown pollinose, genae darker, greyish. Beard yellowish brown. First two antennal segments yellowish with darker hairs, third segment wholly jade green, though this color will probably fade on long preservation. Palpi yellowish brown, black haired, rather stouter and more tapered than usual in this group. Proboscis greenish black, but little longer than palpi, the labella fleshy.

Mesonotum and scutellum light yellowish brown in ground color, obscurely striped, thinly clothed with yellowish pollen. Anteriorly the mesonotum is clothed sparsely with yellow hairs to the level of the transverse suture, except in the middle where a tongue of black hairs extends forward. Black hairs cover the posterior half of the scutum to the scutellar border, with a few yellow hairs at the lateral margins. Scutellum with yellow hairs. A denser tuft of black hairs before and above wing bases. Pleura and sternum yellowish brown, thinly pollinose and thinly pale haired. Wing with subepaulet thin, acutely pointed and with but a very few setae. Costa, subcosta and first vein setose above. Wing hyaline, slightly yellow brown tinged. Area below stigma, base of first submarginal cell (R_2) and, more faintly, base of first posterior cell (R_5) and middle of discal cell (1st M_2) brownish infuscated. There is a slight cloud along vein Cu_1 and the costal cell is quite yellow. The whole wing picture is faint, dilute. The veins, especially proximal to the stigma, are yellowish with a green tinge. Fore coxae brown, femora black, tibia black, but somewhat paler basally, tarsi black. Mid and hind legs dusky brown, the apices of femora and tibiae, and tarsi, darker.

Abdomen dull pale horn-colored with a slightly greenish cast, the third to fifth segments considerably darker. First tergite and anterior border of second, posterior border of fifth and all of remaining tergites clothed with pale straw-colored hairs. Major part of second, all of third and fourth and most of fifth tergites black haired. Lateral posterior angles of all but the third and fourth tergites with pale hairs. Sternites wholly pale haired. When first collected, the whole insect had a greenish tinge, probably due to green blood such as is found in a number of Tabanidae.

Holotype female, Almirante, Bocas del Toro Prov., Panama, 30 July, 1952, taken at a mosquito catching platform 39 feet above ground level between 5 and 9 p.m.

This species is placed here on the basis of the very narrow frons, unicolorous eyes, and pictured wings. The nearly bare subepaulets and greenish tinge are unusual features, but the male of *caliginosus* shows rather sparse setae on the subepaulet also.

Tabanus (Philipotabanus) nigrinubilus sp. nov.

Plate II, fig. 8

Female.—Length 10.5–12 mm., of wing 11–13 mm. Eyes bare, unicolorous, probably greenish black or bronzy in life. Frons very narrow, about 10.7 times as high as basal width, steel grey pollinose, the callus black, slender, ridge-like. Vertex with a slightly raised subshiny patch, sometimes with a vestige of the anterior ocellus. Sub-

callus yellowish grey, frontoclypeus and genae dark steel grey pollinose. Beard sparse, of black and pale grey hairs intermixed. First two and more or less of the base of third antennal segments dusky yellowish brown, remainder of third segment including style black. Palpi dusky yellowish brown, densely black haired. Proboscis slightly longer than palpi, blackish, the labella large and membranous.

Mesonotum and scutellum dark cinnamon brown to practically black, obscurely striped, thinly greyish pollinose and sparsely black haired. Pleura and sternum pale grey pollinose, sparsely pale haired. Wings with subepaulet acutely pointed, densely black setose. Wing pattern as in *caliginosus*, but more intensely black, the hyaline fenestrae about the fork of third vein and end of discal cell very small, and the black band extending practically to the ends of the basal cells. Fore legs practically black, mid and hind femora basally black, the apices and tibiae and tarsi lighter, dusky yellowish brown.

Abdomen black or nearly so, subshiny, the first tergite thinly greyish pollinose. The first tergite bears sparse white hairs as do the extreme sides of second and third tergites and the fourth tergite bears a small and rather indistinct triangle of silvery white hairs, otherwise the the tergites are clothed with rather sparse black hairs. Beneath, the abdomen is subshiny, sparsely grey pollinose, the first three tergites clothed with sparse pale hairs, the remainder largely with black hairs.

Holotype female, Almirante, Bocas del Toro Prov., Panama, 4 July, 1951. Taken in a Shannon trap at Yellow Fever station A, ground level.

Paratypes, 1 female same data as holotype; 1 female same locality as holotype, 16 June, 1951, attacking man at Yellow Fever station D, ground level; 6 females Santa Fe, Veraguas, 18–23, 24, 26 and 31, May, 1950, 5 Aug., 1950 (2), all attacking man at Yellow Fever station C, ground level.

This species is closest to *caliginosus*, but differs in narrower frons, more slender antennae, and greater extent of black wing markings. It occurs with *caliginosus* at Almirante, with no intergrading, and at Sta. Fe with a very distinct dark form of *caliginosus*.

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COMPOSITION OF THE ODOROUS SECRETION OF TRIBOLIUM CASTANEUM

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The abdominal and thoracic odoriferous glands of adult flour beetles, *Tribolium castaneum* (Herbst), *T. confusum* J. du V., and *T. destructor* Uyttenb., contain a pungent, irritating liquid (Roth, 1943; Palm, 1946). Flour in which the beetles have built up a large population becomes pink in color due to contamination by this secretion (Chittenden, 1896; Payne, 1925; Chapman, 1926). This substance has been variously described as similar to cresols and phenols (Palm, 1946), aldehydes (Chapman, 1926), and quinones (Roth and Howland, 1941). Roth and Howland (1941) isolated the odorous material of *T. confusum* by passing dry air into a flask containing the beetles and then through a dry-ice trap in which the secretion collected as yellow-brown crystals. At room temperature the substance was a fairly volatile liquid with a pungent, quinone-like odor; it reduced KI starch paper readily.

Using this same method of isolation, Alexander and Barton (1943) obtained, from *T. castaneum*, yellow crystals melting at 32° C. The product was reduced with sulfurous acid to give a white crystalline product melting, after 4 recrystallizations, at 101–102° C. (2-ethyl-1,4-dihydroxybenzene m.p. 114° C.; 2-methyl-1, 4-dihydroxybenzene m.p 125° C.). Carbon and hydrogen analyses gave values intermediate between those of the methyl- and ethyl-derivatives. The ultraviolet absorption curve of the quinone showed a maximum at 245 mμ (2-methyl-1,4-benzoquinone, 245 mμ; 2-ethyl-1,4-benzoquinone, 246 mμ). Electrometric titrations with N/25 ceric sulfate gave an oxidation equivalent of 67 (2-methyl-,62; 2-ethyl-,69). These data indicate a mixture of methyl- and ethylquinones. Essentially the same results were obtained from an analysis of the secretion of *T. confusum*.

In more recent work Hackman *et al.* (1948), using *T. confusum* and *T. castaneum*, isolated the secretion as the hydroquinones by immersing the beetles in sulfurous acid. They conclusively identified the presence of the main product as 2-ethyl-1,4-dihydroxybenzene from melting points, mixed melting points, and analyses of the dihydroxybenzene and its dibenzoate. In addition, they succeeded in tentatively identifying the presence of 2-methyl-1,4-dihydroxybenzene.

The odorous secretion of *T. castaneum* was found to act as a repellent toward these insects. The present work is concerned with the direct isolation of the chemically unchanged components of the secretion and the determination of those constituents responsible for repelling the beetles.

[1]The writers thank Mr. Paul Bernhardt for technical assistance and Dr. G.V.B. Herford, Director of the Pest Infestation Laboratory, Slough, Bucks, England, for cultures of *Tribolium destructor* and *Latheticus oryzae*.

ISOLATION OF THE SECRETION FROM T. CASTANEUM

About 74,000 adults of *T. castaneum* were placed in a 1-liter round bottom flask and the insects frozen by immersing the flask in a dry-ice-methylcellosolve bath. A nitrogen inlet tube reached to the bottom of the flask so that the gas, passing up through the mass of insects, carried with it the volatile secretion of the glands. Following the flask was a dry-ice trap through which the vapors passed. On evacuating the system to 1 mm. pressure and warming the beetles to 40° C., yellow crystals together with considerable quantities of ice began to collect in the trap. Sublimation was continued at 40° C. for 18 hours during which time most of the product was obtained. A small additional quantity was obtained by heating the beetles to 80° C. for 6 hours.

The crude product was dissolved in ether and after evaporation a 2-phase liquid system remained, a lower, brown layer and an upper, yellow layer. This crude material was sublimed, at room temperature and 0.1 mm. pressure, onto a dry-ice-cooled condenser. The end of the condenser next to the sublimation surface was insulated from the dry-ice by a one-inch plug of glass wool. In this way deep-yellow needles were collected on the cold portion of the condenser while a pale-yellow oil condensed on the warmer end of the condenser and dripped back into the sublimation tube. Thus a fairly clean separation of the crystalline product from the oil was obtained. The crystalline product, amounting to 1.8 g., melted at 33–49° C. It was subjected to batchwise countercurrent crystallization from diethyl ether and then from 35–60° C. petroleum ether. Two yellow crystalline products were isolated:

Compound A—Less soluble fraction; 113 mg.; m.p. 67–67.3° C.

Compound B—More soluble fraction; 1.4 g.; m.p. 37–38.7° C.

After removal of the oil layer (0.6 g.), a small amount of dark-brown, viscous material remained. Sublimation at 80° C. and 0.1 mm. pressure yielded a few greenish-yellow crystals (Compound C) melting at 143.5° C.

The isolation of these products from batches of 25,000 to 75,000 beetles was continued until from a total of approximately 1,850,000 insects (about 3238 g.) the following yields were obtained:

Mixture of Compounds A and B	30 g.
Compound C	44 mg.
Oil	15 g.

The crude material and the purified fractions were stored in a refrigerator.

CHEMICAL IDENTIFICATION OF THE COMPONENTS OF THE SECRETION

1. Compound A—Compound A, m.p. 67–67.3° C., gave no depression in melting point on admixture with authentic toluquinone (m.p. 68–69° C.).

Anal. Calcd. for $C_7H_8O_2$: C, 68.9, H. 4.95. Found: C, 68.9; H, 5.10.

Derivatives: (a) 2-Methyl-1,4-Dihydroxybenzene (Toluhydroquinone): One hundred mg. of Compound A were dissolved in 35 ml. water by warming slightly, and sulfur dioxide bubbled through for 5 minutes to produce a colorless solution. This was extracted 4 times

with 25 ml. volumes of ether; the ether extract was then dried and evaporated. A syrup remained which was dissolved in 5 ml. benzene and boiled to remove water. A white crystalline product was obtained on cooling. After recrystallization from benzene, the product melted at 125° C. Synthetic toluhydroquinone melted at 125–125.5° C., and no depression in melting point was observed on admixture with the derivative from the natural product.

(b) 4-5-Dibromo-1-methylcyclohexene-1-dione-3,6: To a solution of 100 mg. of Compound A in 0.5 ml. of dry chloroform, was added a solution of bromine in dry chloroform at 0° C. until no more bromine was taken up. The chloroform was allowed to evaporate leaving a syrup which, upon scratching and cooling, crystallized as pale-yellow prisms. Recrystallization from alcohol yielded a product with a m.p. of 55–59.5° C. The product obtained by the analogous bromination of synthetic toluquinone also melted at 59–59.5° C. with no depression in melting point upon admixture of the 2 products.

2. Compound B—This consisted of bright-yellow crystals, m.p. 37–38.7° C. which gave no melting point depression on admixture with a sample of synthetic ethylquinone (m.p. 39.5° C.).

Anal. Calcd. for $C_8H_8O_2$: C, 70.6; H, 5.92. Found: C, 70.0; H, 5.68.

Derivatives: (a) Ethylquinhydrone: To a solution of 100 mg. of Compound B and 100 mg. of synthetic ethylhydroquinone in 1 ml. of 95% alcohol was added 0.7 ml. of water. Upon cooling in a dry-ice bath, blue-black crystals of the quinhydrone formed readily. These were filtered on a cold funnel and washed with 0.5 ml. of 55% alcohol. The crystals melted at 79–80° C. while the analogous product from synthetic ethylquinone melted at 81–82° C. No depression in mixed melting point was observed.

(b) Benzyl Mercaptan Adduct: One hundred mg. of Compound B plus 100 mg. of benzyl mercaptan were dissolved in 5 ml. of ligroin (70–90° C.). On standing overnight and allowing part of the ligroin to evaporate, blue-black crystals, m.p. 76–78° C., were obtained. No melting point depression was observed on admixture with the analogous product from synthetic ethylquinone (m.p. 77–78° C.). On moistening with alcohol, both products turned to orange-colored crystals which regained their blue-black color on drying.

(c) Ethylhydroquinone: This was prepared by the same procedure as for toluhydroquinone. Crystallization from chloroform, benzene, and heptane as well as sublimation failed to give a pure product. Purification was finally achieved by rapidly crystallizing twice from water. The product melted at 115–115.5° C. and showed no depression on admixture with synthetic ethylhydroquinone.

3. Compound C—This compound was resublimed at 0.5 mm. pressure and 80–90° C. to give yellow crystals which melted at 143.5° C.

Anal. Calcd. for $C_7H_6O_3$: C, 60.9; H, 4.38. Found: C, 60.9; H, 4.41.

No derivatives were prepared because of the small amount of material available. No depression in melting point was observed on admixture with 2-methoxy-1,4-benzoquinone (m.p. 144.5–145° C.) obtained by oxidation of o-anisidine with chromic acid.

PHYSICAL IDENTIFICATION OF THE COMPONENTS OF THE SECRETION

In the determination of the ultraviolet absorption spectra of these quinones, using 95% alcohol as a solvent, it was noted that the quinones were unstable and the curves shifted with time (cf. Alexander and Barton, 1943). With ethylquinone, for example, the maximum at 247 mμ disappeared, while a new one appeared at 293 mμ. This change progressed more rapidly in the light and at room temperature than in a dark refrigerator. Figure 1 shows the effect of storage on the concentration of ethylquinone in alcohol. After storage for 24 hours at +5° C., there was a 67% loss of ethylquinone while after 6 days the total loss was 85%. As for the nature of this decomposition, it is possible that the ethylquinone was converted to ethylhydroquinone since a new maximum appeared at 293 mμ, at which point lies the maximum for ethylhydroquinone. In spite of this, however, alcohol was suitable as a solvent for quinones provided the curves were determined soon after preparation of the solution.

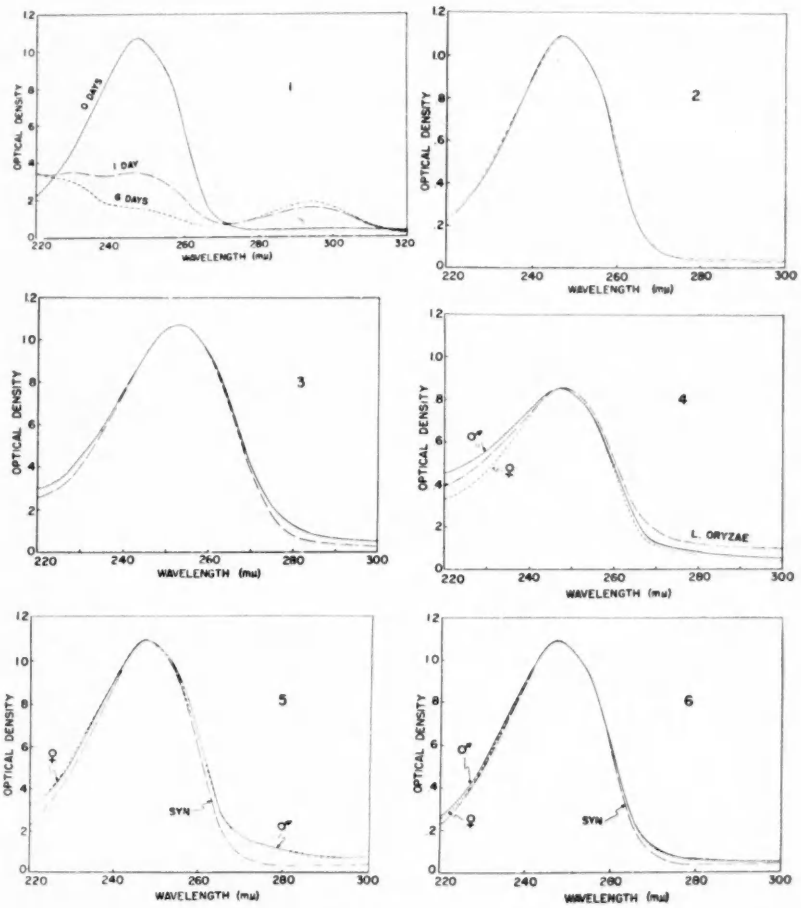
The ultraviolet absorption curves for synthetic ethylquinone and purified ethylquinone isolated from the beetles are shown in figure 2. Both curves are identical. Figures 5 and 6 show the results obtained with secretions from the abdominal and thoracic glands of males and females of *T. castaneum*. The curves for the secretions used in obtaining figures 5 and 6 were collected by cooling the insects in an ice-cooled Petri dish and picking off the crystalline material with a dissecting needle after the substance had flowed from the glands and solidified on the bodies of the beetles (Roth and Howland, 1941). Each curve was determined within a few minutes after the preparation of the solutions from material obtained from several insects. For comparative purposes each curve was adjusted to the same optical density at 247 mμ. Apparently the secretion is similar, as far as quinone content is concerned, in both the thoracic and abdominal reservoirs of both sexes.

The ultraviolet absorption curves of synthetic methoxyquinone and methoxyquinone isolated from *T. castaneum* are shown in figure 3. The curves are essentially identical, with maxima at 252.5 mμ.

The mild conditions under which the quinones were isolated is an indication that these compounds were present as quinones in the beetles and were not formed from other compounds during isolation. This indication is further supported by the ultraviolet absorption curves which were determined within a few minutes after the secretions were removed from the reservoirs of the glands.

Odoriferous glands are found in many tenebrionids (Roth, 1945). An examination of the adults of *Latheticus oryzae* Waterh. revealed that they too have thoracic and abdominal odoriferous glands situated in positions similar to those in *Tribolium*. Ultraviolet absorption curves (fig. 4) were made of the secretions of *T. destructor* by crushing the insects in the solvent and filtering off the solids. The curve for *Latheticus* (fig. 4) was obtained from crude material sublimed from a mixture of both males and females of this species. The maxima of the curves shown in figure 4 indicate that ethylquinone or ethyl- and toluquinones are present in both *T. destructor* and *Latheticus*. Thus at least 4 members of the Tenebrionidae (including *T. confusum*) secrete quinones. The myriapod *Julus terrestris* also secretes a quinone (Béhal and Phisalix, 1900).

The differentiation between toluquinone and ethylquinone by means of ultraviolet absorption is unsatisfactory. Curves for ethylquinone and toluquinone lie so close together with the maxima appearing at 246 mμ and 247 mμ respectively, that differentiation between them is not possible on the Beckman D. U. Quartz Spectrophotometer. However,



FIGURES 1–6. Ultraviolet absorption spectra. FIG. 1. Destruction, with time, of synthetic 2-ethyl-1,4-benzoquinone in alcohol. The solid line (0 days) represents the spectrum of the compound immediately after preparation of the solution. FIG. 2. Synthetic 2-ethyl-1,4-benzoquinone (broken line) and the natural product of *T. castaneum* (solid line). FIG. 3. Synthetic 2-methoxy-1,4-benzoquinone (broken line) and the natural product from *T. castaneum* (solid line). FIG. 4. Odorous secretions from males (♂) and females (♀) of *T. destructor*, and both sexes (combined) of *L. oryzae*. FIG. 5. Synthetic 2-ethyl-1,4-benzoquinone (SYN) and secretions from the abdominal odoriferous glands of males (♂) and females (♀) of *T. castaneum*. FIG. 6. Synthetic 2-ethyl-1,4-benzoquinone (SYN) and secretions from the thoracic odoriferous glands of males (♂) and females (♀) of *T. castaneum*.

the curves are useful for (a) substantiating the chemical evidence for the presence of one or both of the quinones cited, and (b) showing that these quinones are present in *T. destructor*, *L. oryzae*, and the abdominal and thoracic odoriferous glands of both males and females of *T. castaneum*.

POSSIBLE FUNCTION OF THE ODOROUS SECRETION

There has been some speculation concerning the function of the odorous secretion of *Tribolium*. Palm (1946) concluded that the substance serves as a defensive weapon since the secretion is highly toxic

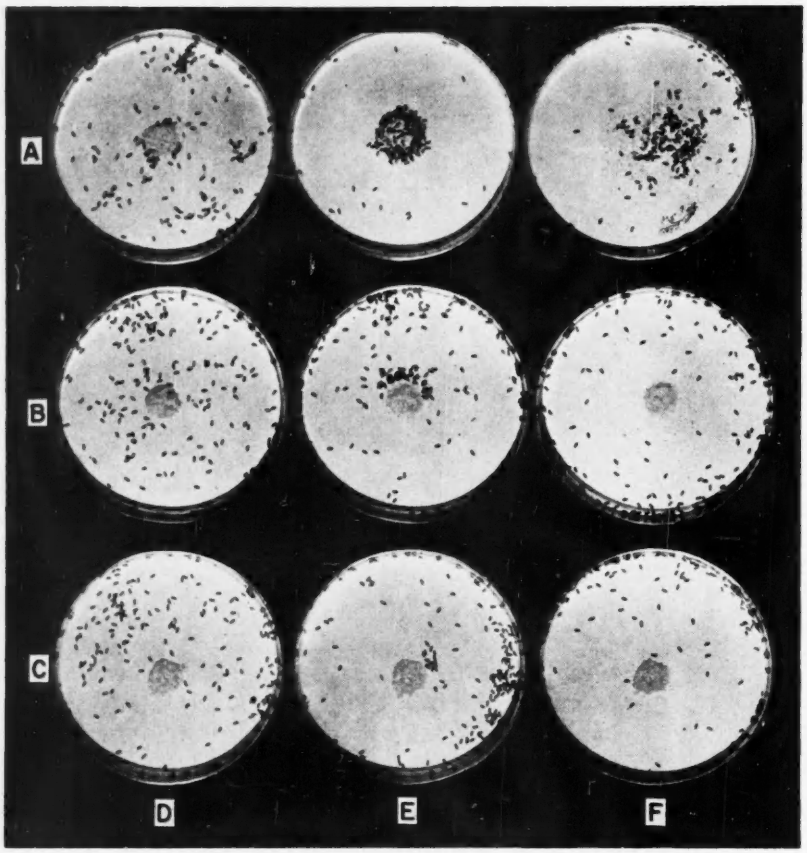


FIGURE 7. Repellent effect of synthetic and naturally occurring ethylquinone towards adults of *Tribolium castaneum*.

Horizontal rows: A = untreated flour; B = flour covering 5 mg. of ethylquinone obtained from adults of *T. castaneum;* C = flour covering 7 mg. of synthetic ethylquinone.

Vertical rows: Time after introduction of the beetles. D = 30 seconds; E = 10 minutes; F = 2 hours.

(Tests performed in darkness; 200 beetles per dish.)

to the beetles themselves (cf. Gough, 1939; Shepard, 1943), has a disagreeable odor, and is discharged when the beetles are disturbed. However, Roth (1943) has pointed out that there are relatively few insect enemies of *Tribolium* which infest flour and that the odorous secretion does not prevent the adult beetles from becoming infested with mites. Species of *Tribolium* have been found under the bark of trees and in old logs (Good, 1936; Butler, 1949), and it is possible that in these habitats the odorous secretion is employed as a means of defense. That the secretion from *T. castaneum* is a repellent was shown by the following experiments.

Adults of *T. castaneum* which had been starved for 5 days prior to performing the tests were used. Beetles in this state of nutrition are strongly attracted to flour (Willis and Roth, 1950). The test method was based on opposing this attraction toward flour by a repellent. A 15 cm. Petri dish having a disc of filter paper on the bottom contained the insects. Five mg. of powdered ethylquinone, obtained from the beetles, covered by about 0.2 g. whole wheat flour was placed in the center of the dish. Two hundred beetles were distributed at random around the edge of the dish and their behavior toward the flour was noted. Figure 7 shows the results of this test together with tests showing the behavior of beetles towards untreated flour and flour covering a powdered layer of 7 mg. of synthetic ethylquinone. Whereas the untreated flour was quickly invaded by the starved beetles, the mounds of flour placed over the synthetic and natural occurring ethylquinones were more or less intact after 2 hours. Tests with the naturally occurring toluquinone and methoxyquinone showed that the former was repellent while the latter failed to repel the beetles.

EFFECT OF THE ODOROUS SECRETION ON POPULATION GROWTH

It is well known that the activities of *Tribolium* in flour result in the medium becoming altered or "conditioned" (probably nutritive depletion and an increase in the concentration of waste products) and that the population declines largely through reduction of the reproductive rate (Allee *et al.*, 1949). It has been suggested that the odorous secretion may be one of the factors responsible for the decline of *Tribolium* populations in conditioned flour (Roth, 1943; Alexander and Barton, 1943). The following experiment was performed to test this hypothesis by observing the growth of populations in flour conditioned by the secretion. When recently-killed adults of *Tribolium* are placed in flour, the medium eventually becomes pink as a result of the volatile quinones being picked up by the flour. The pink flour fails to discolor KI starch paper, whereas discoloration of this paper is a test for the odorous secretion of *Tribolium* (Roth and Howland, 1941); also when mixed with hydroquinone the pink flour does not become blue-green (quinhydrone) which color is obtained when living beetles or crystals of synthetic ethylquinone are crushed with hydroquinone. It appears that the secretion no longer exists as quinones once it discolors the flour (*cf.* Alexander and Barton, 1943). Four different media were prepared by conditioning whole wheat flour with dead beetles. This method of conditioning the flour eliminated the nutritive depletion resulting from feeding insects. The beetles were

killed with chloroform vapor and placed in a refrigerator overnight. The dead insects were then mixed with finely ground flour and enclosed in weighing bottles for 3 days in an incubator at 30° C. and about 70% relative humidity. Each of the 4 media was prepared with one of the following concentrations of dead adults: (a) none (control); (b) 50 beetles/g. flour; (c) 150 beetles/g. flour; (d) 250 beetles/g. flour. At the end of 3 days the flour samples containing dead beetles were placed in open dishes in the incubator for 2 weeks. By this time the contaminated flour had become noticeably pink, those samples with the heaviest concentrations of dead beetles being the darkest in color. The flour was then sifted through an 80-mesh sieve and the dead beetles removed. A pair of living adults of *T. castaneum* was then introduced into 20 g. of each medium (4 replicates). Fecundity records of the females had been kept for 4 days prior to the start of the experiment; the oviposition rates of the females selected for the experi-

TABLE I

GROWTH OF POPULATIONS (ADULTS) OF TRIBOLIUM CASTANEUM IN FLOUR CONDITIONED BY DEAD ADULTS

NOTE: The number is the mean of 4 populations; each replicate was seeded with 1 pair of adults; census taken after 163 days.

Extent of Conditioning of Flour	Mean Number ±Standard Error of Adults (Living + Dead)	Mean Number ±Standard Error of Dead Adults
Uncontaminated flour (control)	142 ± 17.6	4.2 ± 1.9
50 dead beetles/g. flour	154 ± 3.1	5.2 ± 1.4
150 dead beetles/g. flour	104 ± 6.5	4.8 ± 1.0
250 dead beetles/g. flour	105 ± 13.7	6.0 ± 1.0

ment did not differ significantly from one another. The populations were allowed to build up for 163 days at the end of which time a census of adults was taken. The results are shown in Table I. Although the adult populations of the two most heavily conditioned media were somewhat lower than the controls, the differences between them and the control are not significant. Though this data is inconclusive it does indicate that, with the above experimental procedure, the conditioning of flour by quinones from flour beetles has relatively little influence on the increase of an adult population of *Tribolium*.

SUMMARY

The odorous secretion of *Tribolium castaneum* was sublimed directly from more than 1.5 million freeze-killed insects at 1 mm. pressure and 40° C. The yellow crystalline product, collected in a dry-ice trap, was purified by fractional crystallization and sublimation. Three different quinones were identified by melting points, suitable derivatives, and ultraviolet absorption spectra. Of the quinones present in the odorous secretion of *T. castaneum*, 80–90% was 2-ethyl-1,4,-benzoquinone,

10–20% was 2-methyl-1,4-benzoquinone, and there was a trace of 2-methoxy-1,4-benzoquinone.

Ultraviolet absorption data showed that ethyl-and/or toluquinone were present in *Tribolium destructor*, *Latheticus oryzae*, and the abdominal and thoracic odoriferous glands of both males and females of *T. castaneum*.

Qualitative repellency tests, using *T. castaneum*, were made with the 3 quinones isolated from the adult beetles. The test method was based on the fact that starved beetles were strongly attracted to flour, and a repellent substance, when introduced into the flour, opposed or prevented this attraction. Of the 3 naturally occurring quinones tested, the ethyl- and toluquinones were repellent while the methoxy-quinone failed to repel the beetles.

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BRYOBIA CURIOSA, NEW SPECIES, FROM THE MOJAVE DESERT IN CALIFORNIA

(Acarina: Tetranychidae)

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University of California, Davis

The phytophagous mite herein described was taken from one or more shrubs on the northern fringe of the Mojave Desert, California. This type locality very nearly coincides with that of *Pseudobryobia drummondi* (Ewing) described from the creosote bush, *Larrea tridentata*, in nearby Death Valley, California.

The new desert species is interesting chiefly because it is not wholly congeneric with *Bryobia* Kock, 1836 or with *Pseudobryobia* McGregor, 1950. The simple termination of each collar trachea on the lateral integument ensheathing the stylophore, without a projecting "glomerulus" or free lobe, is as described for *Pseudobryobia*. Otherwise, the general organization of the body and appendages, chaetotaxy, surface sculpturing and location of the four "frontal" setae on elevated lobules are Bryobia-like. The inclusion of the new species in *Bryobia* appears to be the better alternative.

Bryobia curiosa sp. nov.

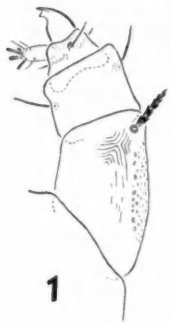
Female.—General body plan as in *Bryobia praetiosa* Koch *sensu lato*. Integument covering dorsum of propodosoma finely tuberculate near mid-line, tubercles diminishing laterally to intergrade with longitudinal striae near margins (fig. 3); dorsal integument of hysterosoma coarsely striated, transversely across middle and longitudinally on margins. Hysterosoma with a dimple-like dorsal pit or depression in posterior mid-line. Dorsal setae, including frontals (verticales), 32 in number; all spatulate, ribbed fanwise and minutely spiny on convex face (fig. 4); mostly of similar size and shape, approximately 2.3 times as long as greatest width. Each of four frontal setae arising from a small, separate lobule on anterior margin of propodosoma. Two pairs of eyes, posterior pair with lens-like refractile sphere. Stylophore (mandibular plate) tapering to a blunt, bifid tip in front (fig. 6), anterior cleft deep, conspicuous. Collar tracheae or peritremata almost straight tubes diverging anteriorly from points of origin between basal lobes of mandibular plate and terminating in sidewalls of its eversible

EXPLANATION OF PLATE

FIG. 1. Median aspect of right palpus. FIG. 2. Details of palpal tarsus and claw. FIG. 3. Dorsal view of body showing surface markings of left side. FIG. 4. Dorsal setae; left to right, lateral frontal (vertical), median humeral, lateral caudal. FIG. 5. Tip of Tarsus I, lateral view. FIG. 6. Anterior portion of body and gnathosoma drawn from above to illustrate frontal setae, collar tracheae and mouth parts. FIG. 7. Tip of left tarsus IV from above.

Bryobia curiosa, n. sp
F. M. Summers

PLATE 1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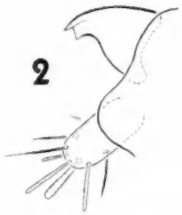
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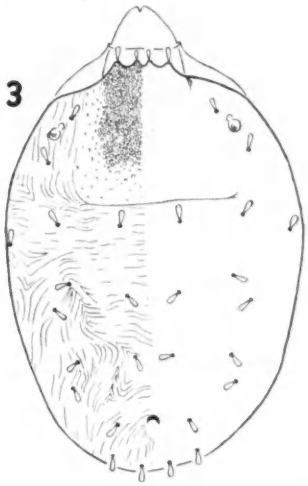
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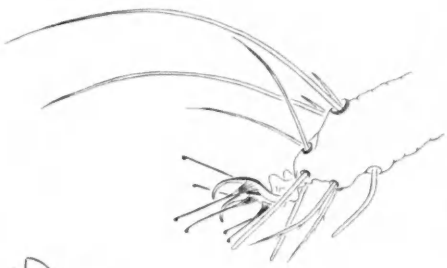
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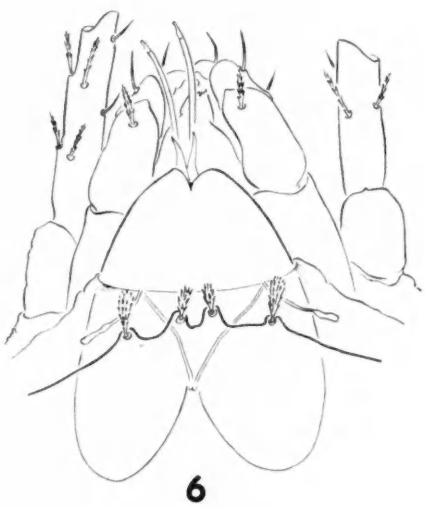
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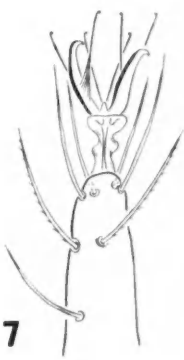
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sheath; outer or distal end of each peritreme a simple, cylindrical end-chamber, having no free lobe projecting from surface of integument. External face of palpal femur with tuberculate sculpturing as on propodosoma (fig. 1); palpal tarsus provided with seven setae of several types, including one distinct claviform sensilla having annular supports in its walls (fig. 2). Tarsus I with two sets of duplex setae at same level (addorsal, opposite) on upper surface near pretarsus (fig. 5); each consisting of a long slender seta called a solenidium by Grandjean, 1935–6 (*ex* Vitzthum, 1941), and a short seta of undetermined type. Tarsus II with only three corresponding setae; duplex setae of equal length and sharing alveolus near caudal margin, the distal element a solenidium and the proximal one a faintly plumose, acicular seta of common type; opposite seta nearer cranial margin not duplex, acicular, faintly plumose. Tarsus III provided with two single plumose setae corresponding in position to duplex setae of tarsus I, and one independent solenidium borne proximad, longer than interval to bases of those in duplex position. Corresponding setae of tarsus IV (fig. 7) as described for tarsus III. Pretarsi of legs I to IV identical in respect to empodia and tenent hairs; each empodium is a small spur provided with one pair of capitate tenent hairs; two longer capitate tenent hairs, one inner and one outer, arising from several roots at base of each claw (figs. 5, 7).

Average dimensions of idiosoma determined from 10 specimens mounted in Berlese fluid: L.-0.61 mm., W.-0.46 mm.

Male.—Unknown.

Host Plants.—Not recorded. Probably taken when the shrubs *Chrysothamnus*, *Erigonum* and/or *Artemesia* were being beaten in the type locality.

Type Locality.—Mojave Desert, along U.S. Highway 396 between Johannesburg and Kramer Junction, California. Elevation about 4,500 ft.

Type Material.—Fourteen mature females collected April 19, 1949 by S. F. Bailey and the author. Designated type specimen and 3 paratypes deposited in the collection of the United States National Museum, U.S.N.M. No. 1985. Others retained in author's collection.

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ON THE EARLY STAGES OF NEOPACHYGASTER MACULICORNIS (HINE) AND BERKSHIRIA ALDRICHI (MALLOCH)

(Diptera: Stratiomyiidae)[1]

EDWIN F. COOK

Although the larva of the Stratiomyiidae have received some attention from entomologists in the past, details of the biology and larval descriptions are extremely sketchy, at least for the North American fauna. The larva of *Neopachygaster maculicornis* (Hine) has been described by both Malloch (1917) and by Greene (1917). The larva of *Berkshiria aldrichi* (Malloch) is herein described for the first time. In regard to the description of *N. maculicornis*, however, Malloch illustrates only the apex of the abdomen and presents but a brief description while Greene presents only a small dorsal view of the whole larva. Neither of the illustrations is particularly accurate nor detailed enough to permit identification. In fact, the descriptions and illustrations by Malloch and Greene of *Neopachygaster* and that by Peterson (1951) of *Zabrachia* sp. could apply equally well to either of those two genera or to *Berkshiria*. Johannsen (1922) did, however, indicate a character which permits the separation of *Zabrachia* from the other two genera although this is not cited by Peterson. For these reasons, the larva of *N. maculicornis* will be redescribed and illustrated in addition to the description of the previously unknown larva of *B. aldrichi*.

Malloch (*ibid.*) indicates that the larva of *N. maculicornis* were found under the bark of a fallen elm at White Heath, Illinois in March, April, and October 1916. The specimens described by Greene were collected in November, 1912 at Falls Church, Virginia from beneath the bark of a tulip tree (*Lirodendron*) in sap between the wood and the bark. The larvae of this species here described were found in the loose, laminate inner bark of a fallen and decaying cottonwood (*Populus deltoides*) in Ramsey County, Minnestoa on April 28 and May 23, 1951 and under the bark of a dead poplar (*Populus* sp.) in St. Paul, Minnesota on November 12, 1951. They were also collected from beneath the bark of a dead but standing quaking aspen (*Populus tremuloides*) at Basswood Lake, Lake County, Minnesota on July 11, 1951. The larvae are most active where the bark is moist but not wet.

Verrall (1909) states his belief that the larvae of the Pachygastrinae are most probably quite specific in regard to the species of dead trees which they inhabit. From the records of this species, however, little specificity is apparent, since they have been collected from species of trees representing three different families: Salicaceae, Ulmaceae and Magnoliaceae. It may be that this species is limited only to those dead or dying deciduous trees which have a loose, laminate inner bark.

[1]Paper No. 2799, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul 1, Minnesota.

The habitat occupied by the larvae here described was also occupied by a number of other arthropods. Mites (Parasitinae) and Collembola are quite abundant as are the larvae of several species of Diptera. The Diptera include: ***Lonchea polita*** (Loncheaidae), ***Euxesta*** sp. (Otitidae) (both noted also by Malloch), ***Berkshiria aldrichi*** (Stratiomyidae) and one undetermined species each of Anthomyiidae, Sciaridae and Tipulidae. No evidence of predation on or by any of these species has been observed although Malloch (*ibid.*) indicates that it might occur. One specimen of *N. **maculicornis*** was observed to feed on a wounded member of its own species. The mouth parts of this larva are much like those of ***Odontomyia alticola*** James (Cook, 1949) so it may be assumed that the food consists largely of microorganisms, fungus spores, et cetera which are swept from the surface by the mandibular-maxillary brushes. The mouth parts are in constant motion, continuously sweeping the moist surface film on which the animal moves. Verrall (*ibid.*) indicates that the Pachygastrinae in general are associated with the frass of wood boring beetles, but this has not proven to be the case in this species.

The duration of the larval period is unknown since all the larvae found on the two dates cited were apparently last instars with a size range of from 5.50 to 6.00 mm. It is probable, therefore, that this species overwinters as a larva. Adults began to emerge by May 21 from those larvae collected on April 28 and continued until June 15 when the culture became desiccated. On July 16 moisture was introduced to the culture vials, and the larvae became active again and pupated. These emerged between July 20 and 23. Apparently, then, these larvae can survive at least one months desiccation without injury.

Pupation, as is already known, occurs within the last larval skin, and the only means by which pupae can be distinguished from the larvae is by cessation of activity and an increase in the transparency of the head as the pupal head is drawn into the thorax. By isolating larvae the pupal period was found to last for 8 to 10 days. The ovaries of the newly emerged females contain only small undeveloped eggs. It is probable, therefore, that at least several days must elapse before oviposition occurs. Adults live for no more than five days when confined to the culture vial. The food of the adults is unknown. It has been noted by Hull (1930) that adults are often taken at windows although he also indicates that Pachygastrinae are more often collected by sweeping in woods in which decaying logs are present.

Berkshiria aldrichi was collected in small numbers in company with *N. **maculicornis*** from a fallen ***Populus deltoides*** in Ramsey County, Minnesota on May 23, 1951 and again in company with a few *Solva* sp. under the bark of a dead but standing ***Ulmus pumila*** at the University Farm Campus, St. Paul, Minnesota on July 3, 1951. Several instars and a long range of sizes were collected at this time. Unfortunately, before it was realized that this series was distinct from *N. **maculicornis***, most of the larvae were placed in alcohol and no further study of the life cycle could be made by rearing. However, three instars in addition to the final one can be recognized by morphological means. These may be all that exist or there may be five or more. Again, unfortunately of 166 specimens measured, there is a continuous intergradation of

of sizes from the smallest to the largest with no obvious segregation into distinct size groups. It must suffice at the moment to say that there are at least four morphologically distinct larval instars. The pupal period was determined to be 8 days.

Neopachygaster maculicornis: LAST STAGE LARVA AND PUPA

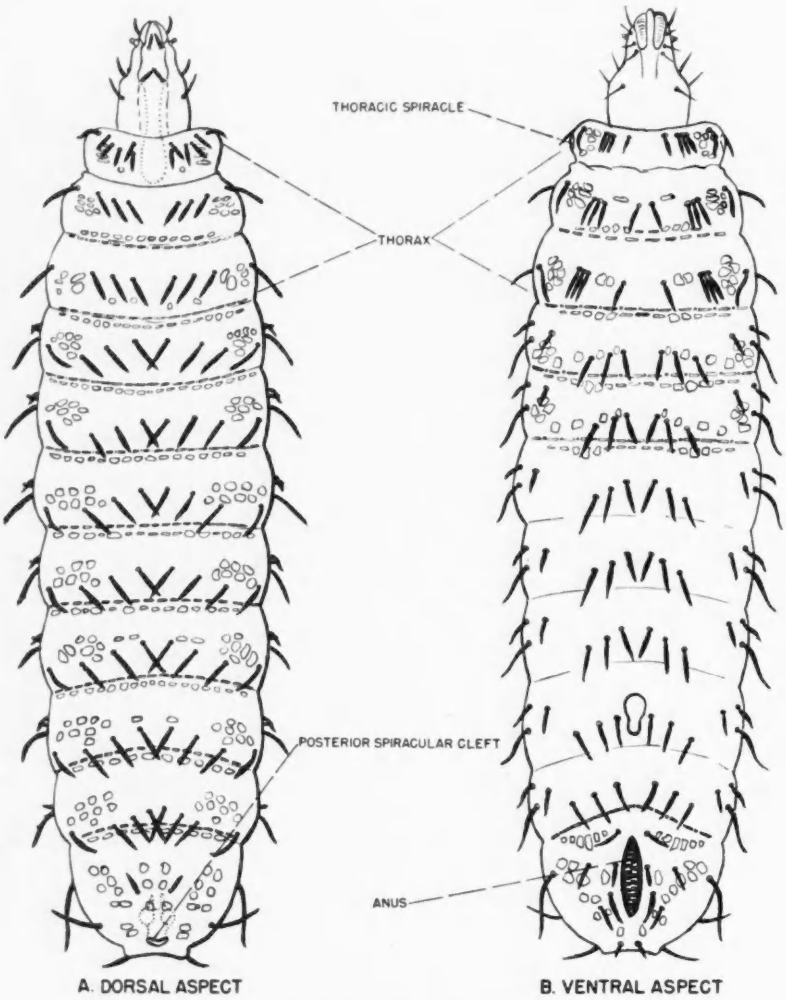
(Plate I)

Total length 5.50 to 6.00 mm.; width 1.40 to 1.50 mm.; much flattened dorsoventrally; head length slightly more than 0.10 total length. Setae of the body short, none more than 0.30 mm.; postanal setae short, 0.07 mm. The thorax and abdomen light to dark grey; head yellow darkening to amber anteriorly; setae amber yellow. The cuticle of the head is finely and irregularly reticulate while that of the thorax and abdomen is conspicuously shagreened (Plate III, fig. C). The distribution of the larger plaques is indicated in Plate I (omitted on abdominal sterna 3 to 8). This pattern is apparently quite specific, particularly as to the shape and size of those plaques occurring between segments (compare Plates I and II). Plaques fairly large, up to 0.07 mm. across; three pair of median plaques on the dorsal surface of segment eight. On the sternum of abdominal segment six there is a pale patch in which the shagreened pattern is absent and which is regularly marked with small dark spots. In this species this has the shape of a keyhole. Setae distributed as in Plate I; all densely short plumose as in Plate III, figures H and I. There are three pair of setal groups on the thoracic sterna, each with three setae arranged close together in a transverse row. Antennae short, two-segmented (Plate III, fig. D) arising laterally just posterior to the base of the mandibular-maxillary complex. Prothoracic spiracles on slightly elevated, heavily sclerotized, amber-brown plates on either side of the prothorax (Plate III, fig. G); posterior spiracles with-drawn into a respiratory chamber on tergum of abdominal segment eight.

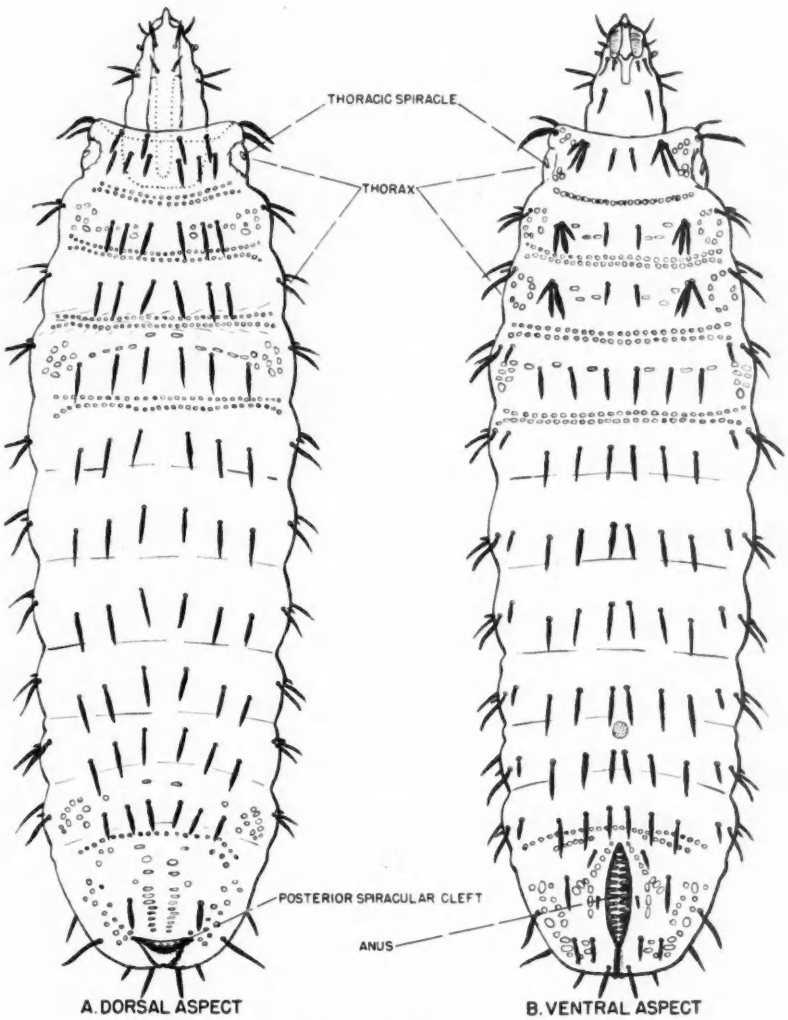
Berkshiria aldrichi, LAST STAGE LARVA AND PUPA

(Plate II)

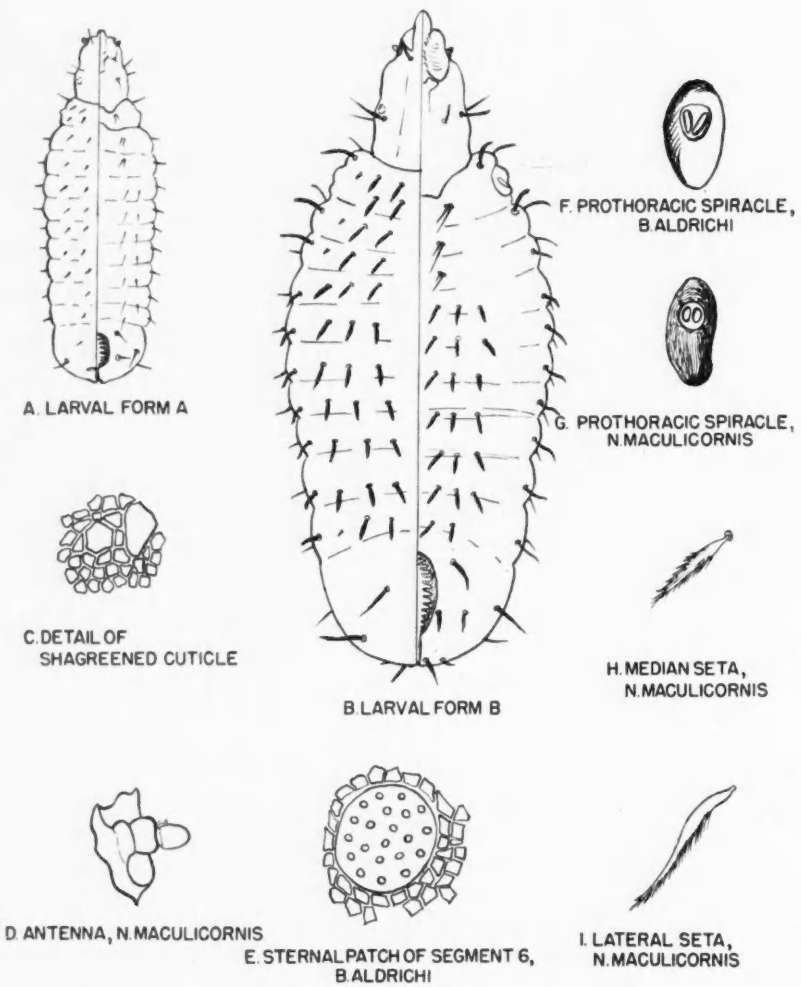
Total length 5.00 to 7.20 mm.; width 1.6 to 2.00 mm.; dorsoventrally flattened; head length slightly more than 0.10 total length. Body setae short, as in *N. maculicornis*, no more than 0.26 mm.; postanal setae longer than in *N. maculicornis*, 0.23 mm. Abdomen and thorax dark grey to near black; head yellow darkening to amber anteriorly; setae amber-yellow. The head cuticle is finely reticulate as in the preceding species, and the abdomen and thorax are shagreened. The larger plaques are distributed as in Plate II. These are slightly smaller than in the preceding species, 0.05 mm., and more numerous; eight to ten pairs of median plaques on tergum of segment eight. The pattern of the plaques is omitted on the sterna of abdominal segments two through seven, and from the terga of segments two through six, as these are all identical with that in segment one. Setae arranged essentially as in *N. maculicornis;* the triads of setae on the sterna of the thoracic segments arranged in the form of a triangle rather than straight trans-



Neopachygaster maculicornis (Hine), last stage larva and pupa.
A, dorsal aspect; B, ventral aspect.



Berkshiria aldrichi (Malloch), last stage larva and pupa.
A, dorsal aspect; B, ventral aspect.


A. LARVAL FORM A
B. LARVAL FORM B
C. DETAIL OF SHAGREENED CUTICLE
D. ANTENNA, N. MACULICORNIS
E. STERNAL PATCH OF SEGMENT 6, B. ALDRICHI
F. PROTHORACIC SPIRACLE, B. ALDRICHI
G. PROTHORACIC SPIRACLE, N. MACULICORNIS
H. MEDIAN SETA, N. MACULICORNIS
I. LATERAL SETA, N. MACULICORNIS

Berkshiria aldrichi (Malloch) and *Neopachygaster maculicornis* (Hine): Early instars and details.

verse rows. Pale patch of sixth abdominal sternum circular (Plate III, fig. E). Prothoracic spiracles differ but little from those in the preceding species (Plate III, fig. F). Antennae and mouth parts essentially identical.

In Plate III, figs. A and B, two earlier instars are illustrated in which morphological differences are apparent. The form illustrated in A is the smallest and is possibly the first instar. Total length 0.74 to 0.93 mm.; head length 0.25 total length; color sordid white; shagreening not apparent although the cuticle is somewhat granular in appearance. This granulation is possibly due to the presence of calcium carbonate crystals in the cuticle since the roughened appearance is lost after treatment with dilute HCl. Setae fewer in number as indicated in the illustration.

Larval form B (Plate III, fig. B). Total length 1.41 mm. to 2.6 mm.; head length from 0.22 total length in smallest specimens to 0.17 total length in the largest; color sordid white, no shagreened pattern developed; setae fewer than in last instar, as illustrated. This form may exist through only one or perhaps through two or more instars as there is a considerable size range.

Larval form C is identical with the final instar in all details except color and size. The color is sordid white, and the size range is from 2.60 to 4.01 mm.

The following table will serve to separate the last instar larvae and the puparia of *N. maculicornis* from *B. aldrichi*.

	N. maculicornis	*B. aldrichi*
1.	Plaques large, up to 0.07 mm	Plaques smaller, 0.05 mm.
2.	3 pairs of median plaques on abdominal tergite 8	7 to 10 pairs of median plaques on abdominal tergite 8
3.	Postanal setae short, 0.07 mm	Postanal setae long, 0.23 mm.
4.	Sternal patch of abdominal segment 6, keyhole shaped	Abdominal patch, circular

These slight larval differences and the very apparent similarity of the adults would seem to indicate a very close relationship between these two forms despite the fact that they are placed in distinct genera. The generic concepts in this subfamily, it should be noted, might be fruitfully re-examined.

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THE ENTOMOLOGICAL SOCIETY OF AMERICA
PROCEEDINGS OF THE FORTY-SEVENTH ANNUAL MEETING

December 15–18, 1952. Philadelphia, Pennsylvania

The Entomological Society of America held its forty-seventh annual meeting at the Bellevue-Stratford Hotel in conjunction with the American Association of Economic Entomologists. The combined attendance numbered about 750. The program for the four-day meeting, including joint sessions with the Association, was as follows:

Monday, December 15

9:00 A. M. Registration.

9:30 A. M. Joint Session. Address of the President of the A.A.E.E., "Insects or Insecticides?" E. F. KNIPLING, U. S. Bureau of Entomology and Plant Quarantine.

10:00 A. M. Joint Session—Panel on Public Relations in Entomology. W. S. MORELAND, moderator.

1:30 P. M. Business Session on Consolidation.

7:30 P. M. First meeting of the American Section of the International Union for the Study of Social Insects. T. C. SCHNEIRLA, presiding.

8:00 P. M. Symposium on Problems in Caste Determination and Functional Specialization in Social Hymenoptera. C. D. MICHENER, presiding.

Tuesday, December 16

9:00 A. M. General Session—Presentation of Papers, PRESIDENT LINSLEY, presiding.

1:30 P. M. Joint Session, Teaching Section A.A.E.E. Symposium on "The Employers' View of Entomological Training," PAUL DAHM, presiding.

1:30 P. M. Physiology Section. Presentation of Papers. R. L. METCALF, Chairman; E. O. TAUBER, Vice-Chairman, S. D. BECK, Secretary.

6:30 P. M. Banquet and Entertainment.

Wednesday, December 17

9:00 A. M. Physiology Section. Symposium on Methods for the Study of Insect Physiology. E. O. TAUBER, presiding.

9:00 A. M. Taxonomy Section. Symposium on the Philosophy of Systematics. G. P. HOLLAND, Chairman; KATHLEEN DOERING, Vice-Chairman; H. E. EVANS, Secretary.

1:30 P. M. Taxonomy Section. Symposium on the Origin and Composition of the Nearctic Biota. H. E. EVANS, presiding.

1:30 P. M. Physiology Section. Presentation of Papers. R. L. METCALF, presiding.

8:00 P. M. Joint Session. Chairmen: E. G. LINSLEY, President, E.S.A., and H. G. JOHNSTON, First Vice-President, A.A.E.E.

1. Annual Public Address of the Entomological Society of America: "Problems of Cuticle Penetration"—A. GLENN RICHARDS.
2. Invitational Address: "Biological and Taxonomic Aspects of the Mite Control Problem"—A. EARL PRITCHARD.

Thursday, December 18

10:30 A. M. Final Business Meeting.

1:30 P. M. Physiology Session. Presentation of Papers. R. L. METCALF, presiding.

1:30 P. M. Taxonomy Section. Presentation of Papers. G. P. HOLLAND, presiding.

Business Session on Consolidation, Monday, December 15

President Linsley called the meeting to order at 1:45 P. M. There were 78 members present. The agenda prepared by the Executive Committee for this special business meeting were read and approved.

The secretary announced the results of the final vote on consolidation. (See the ANNALS, Vol. 45, No. 2.)

President Linsley requested the secretary to read a letter from Karl V. Krombein in which he submitted his resignation in protest against the consolidation of the two societies. The President called attention to the receipt of one other letter that expressed a similar view and offered to have it read upon request from the floor. There was no such request. A brief summary of certain legal aspects leading up to consolidation was presented. The President then expressed his regrets over the action which had been taken by Mr. Krombein and expressed the hope that sometime in the future he would see fit to rejoin the Society. He then asked for comments on the letter which had been read and for expression of any additional personal views in line with those expressed by Mr. Krombein. There was no response to this request.

The next item of business was a call for the report of the nominating committee. President Linsley explained that consideration of this matter before the regular business meeting on Thursday was important in order for the new officers to be able to meet at Philadelphia with the Executive Committee of the A.A.E.E. as the Interim Governing Board of the new E.S.A.

REPORT OF THE NOMINATING COMMITTEE AND ELECTION OF OFFICERS

The nominating committee wishes to submit the following slate of officers for consideration:

President	H. H. Ross
First Vice-President	C. W. Sabrosky
Second Vice-President	C. D. Michener
Secretary	A. C. Hodson
Treasurer	S. W. Frost
Executive committee for 1953	C. F. W. Muesebeck
Executive committee for 1955	T. H. Hubbell, A. F. Braun

Respectfully submitted,

W. J. Brown,
R. L. Usinger,
Alvah Peterson, *Chairman.*

President Linsley asked for nominations from the floor. Paul Woke was nominated for the office of secretary. A motion was made and carried that the secretary be instructed to cast a unanimous vallot for all nominees except those nominated for secretary. Tellers A. C. Cole and Miss L. M. Russell reported A. C. Hodson elected secretary by secret ballot.

In the original report of the Nominating Committee two names were submitted in nomination for the Executive Committee in the class of 1953. Dr. C. E. Mickel called attention to a statement in the Constitution limiting the number of Executive Committee members to five in addition to the officers and the managing editor. The Nominating Committee acted upon this correction by withdrawing one of the names that they had submitted for consideration.

The President read a brief explanation for a series of Resolutions that were recommended for approval by the Society by joint action of the Executive Committee of the E.S.A. and A.A.E.E. The resolutions were read by the Secretary and voted upon individually. All were approved unanimously.

The resolutions acted upon were the following:

Resolutions

The new Constitution of the Entomological Society of America has provisions for the transition period (1953) in Article XIII. These provisions state that the Executive Committees of the amalgamating societies shall constitute an Interim Governing Board and that this group shall have the authority of the Governing Board during the transition period. However, there are no suggestions as to how the many duties of the Interim Board are to be accomplished. For this reason members of the Executive Committees of the two Societies met at Santa Barbara to discuss some of the problems involved. They drew up a set of proposals designed to aid the Interim Board which will assume its responsibilities on January 1, 1953. These proposals have been considered by both Executive Committees separately and then jointly on December 13–14, 1952, and are now presented to the membership of each society.

1. It is moved that (a) the President of one of the amalgamating organizations shall become the President of the new E.S.A. for 1953 and Chairman of the Interim Governing Board;

(b) the other President elected in 1952 shall become the President-Elect as set forth in the new Constitution.

(c) the Interim Governing Board shall determine which of the Presidents shall become President for 1953.

2. In view of the fact that financial and business matters of the new society require immediate attention as of January 1, 1953, and in view of the fact that the

A.A.E.E. affairs are more complicated than those of the old E.S.A., it is moved that, until such time as the Governing Board shall select an Executive Secretary,

(a) DR. CORY be designated as temporary Secretary-Treasurer of the Board and Business Manager of the *Journal;*

(b) DR. CORY be authorized to terminate the business of the A.A.E.E.;

(c) DR. CORY be authorized to conduct the business of the new E.S.A.;

(d) DR. CORY be authorized to employ the necessary clerical and stenographic help to carry out these tasks, the amount not to exceed $500.00 per month; and

(e) DR. JAMES be designated as Business Manager of the *Annals* until such time as transfer can be made to the Office of the Executive Secretary.

3. In view of the fact that funds are necessary immediately and that time will not permit setting of dues in the letter-ballot manner prescribed by the Constitution, it is moved that the Interim Governing Board be authorized

(a) to set the dues for 1953 at $10.00, this sum to include subscription to either the *Journal* or the *Annals*, as selected by each individual;

(b) if both publications are desired by any member, to furnish the second publication for an additional $4.00;

(c) to set the price of the *Journal* and the *Annals* at $10.00 each per year to non-members; and

(d) to supply the *Bulletin* free to all members.

4. It is moved that the Interim Governing Board be authorized to continue the editors and editorial boards of the *Annals*, the Thomas Say Foundation, the *Journal* and all other publications until such time as said positions are filled in the manner prescribed by the new Constitution.

5. It is moved that the Interim Governing Board be authorized to continue the membership of the committees on Entomological Nomenclature, Common Names, and Insecticide Terminology as existing on December 31, 1952, and to appoint such other standing committees as may be necessary to conduct business during 1953.

6. Inasmuch as programs for the next Annual Meeting must be prepared prior to the regular election of Section Officers, it is moved that the Interim Governing Board be authorized to appoint Section Officers to serve in 1953.

7. It is moved that the Chairman of the Interim Governing Board be authorized to appoint councilors, trustees and delegates as may be required to represent the E.S.A. during 1953.

8. Since the new E.S.A. and its Interim Governing Board does not legally act until January 1, 1953, and since it will be both difficult and expensive to get this group together again after this week, it is moved that the members of the Interim Governing Board be authorized to meet as a legal body prior to that date to institute actions authorized by the new Constitution and By-Laws or by the preceding motions after they have been authorized by each of the amalgamating societies, any such actions to become effective January 1, 1953, the date on which the new E.S.A. becomes operative.

The Secretary read the following recommendations which were prepared to be presented to the Interim Governing Board at its first meeting:

RECOMMENDATIONS TO THE INTERIM GOVERNING BOARD

1. A poll of the membership to determine section affiliations for voting purposes should be consummated with the utmost dispatch.

2. A thorough study should be made of both the *Journal* and the *Annals* with respect to:

(a) possible broadening of scope to assure complete coverage of all of entomology between these two publications;

(b) a liberal policy towards publication by non-members, especially in multiple-author articles;

(c) assurance that any E.S.A. member can publish in either the *Journal* or the *Annals* irrespective of which publication he elects to receive; and

(d) possible increase in either pages or frequency of publication of the *Annals*.

3. A thorough study in regard to the use of advertising in all society publications, existing policies to be continued for the present.

4. A thorough study of existing committees for the purpose of continuing those that are needed.

5. Notify all Branches to elect their representatives to the Governing Board

in 1953 to serve beginning in 1954, and to notify all Sections to elect their representatives to the Governing Board and to the various editorial boards.

6. Consider the disposition of reprints and back numbers of the *Annals*.

7. Investigate the desirability or need for legal action in regard to Incorporation of the E.S.A.

8. Investigate the possibility of summarizing the new E.S.A. organization in an article in the A.I.B.S. *Bulletin*.

9. To set up mechanism for continuance of the annual invitational address.

10. To see that "service members" be immediately identified on the rolls and not billed (See Article 1 of By-Laws).

11. To consider establishment of the custom of vice-chairmen of Sections becoming the next chairmen to assure continuity.

12. Approve the meeting place and date for 1953 as agreed on by the joint Executive Committees of the A.A.E.E. and E.S.A.

13. To study the question of the most acceptable dates for the annual meeting and to prepare a long-range plan for meeting places.

14. Consider the desirability of continuing affiliation with the Grass Lands Committee.

A motion to approve these recommendations was made and carried.

President Linsley announced a recess until Thursday morning at 10:30 A. M.

Respectfully submitted,

A. C. HODSON, *Secretary*.

Business Session, Thursday Morning, December 18

President Linsley, presiding

President Linsley called the meeting to order and asked for the report of the Secretary. A motion was made and carried to dispense with the reading of the minutes of the last meeting.

REPORT OF THE SECRETARY

Interim activities of the Executive Committee

PRESIDENT LINSLEY appointed the following Committees:

Program Committee— R. F. SMITH, R. I. SAILER, C. D. MICHENER, Chairman.

Local Arrangements Committee—CHARLES HODGE IV, H. R. ROBERTS, Chairman.

Nominating Committee—W. J. BROWN, R. L. USINGER, ALVAH PETERSON, Chairman.

Auditing Committee—W. J. GERTSCH, W. W. WIRTH, S. E. FLANDERS, Chairman.

Resolutions Committee—A. E. PRITCHARD, A. B. GURNEY, C. E. MICKEL, Chairman.

The President appointed a number of individuals to perform various duties and to represent the society on various occasions. These appointments were as follows:

MR. C. F. W. MUESEBECK was appointed to fill the vacancy in the Executive Committee created when DR. S. W. FROST was elected Treasurer in 1951.

DR. C. H. CURRAN was asked to represent the Society at the inauguration of Lewis Webster Jones as President of Rutgers University.

DR. J. J. DAVIS was appointed Chairman of the Committee for the Encouragement of Gifts and Endowments.

DR. WM. T. M. FORBES was asked to replace DR. J. J. PRATT, JR., as representative on the Council of the A.A.A.S.

The Executive Committee invited DR. A. G. RICHARDS to present the Annual Public Address of the Society.

The Executive Committee approved the President's request for payment of travel expenses to enable the Secretary to attend the joint Executive Committee of the E.S.A. and the A.A.E.E. that was held at Santa Barbara, California.

The applications of 24 individuals were approved for membership.

LELAND CHANDLER	JACK W. POTTER
HUBERT FRINGS	HUBERT W. PRESCOTT
MRS. MABLE FRINGS	BRUCE DOUGLAS PRESSER
ARDEN R. GAUFIN	WILLIAM EDWARDS ROBBINS
HARVEY L. GOLDSTEIN	CHESTER C. ROYS
HAROLD JOHNSON GRANT, JR.	ALEXANDER JULIUS RUDINSKY
CHARLES C. HASSETT	CHARLES W. RUTSCHKY
ROBERT HENRY JONES	THOMAS SMITH, JR.
CARROLL BABBIDGE KNOWLTON	KENNETH WILBURN TUCKER
JAMES B. KRAUSE	NEIL ALLAN WALKER
WALLACE E. LABERGE	CARL M. YOSHIMOTO
JOSEPH R. LARSON, JR.	DAVID A. YOUNG, JR.

Executive Committee Meeting—Philadelphia

The minutes of the 1951 Executive Committee, not included in the Secretary's report published in the *Annals*, were read and approved.

The Committee voted to pay the expenses of the Secretary and the Treasurer incurred by attendance at the Philadelphia meeting. After hearing a brief financial report presented by the Treasurer it was voted to recommend that the Treasurer be instructed to pay on or before December 31, 1952, all outstanding obligations for which he has received bills or precise statements of cost.

The Secretary read the names of members who were lost by death during the year. The deceased were MELVILLE T. COOK, E. C. VAN DYKE, C. O. ESSELBAUGH, H. T. FERNALD, C. P. STROUD, W. R. WATSON and CARL J. WEINMAN. (The members present at the business meeting stood for a moment of silent tribute.) It was voted to recommend to the Interim Governing Board of the new E.S.A. that appropriate committees be appointed to prepare obituaries to be published in the *Annals*.

The Committee voted to declare DR. J. C. BRADLEY, DR. ROBERT MATHESON, and DR. P. S. WELCH as Service Members. The President instructed the Secretary to inform the acting Secretary-Treasurer of the Interim Governing Board of this action and to prepare a list of all Service Members of the Society to be presented to said Secretary-Treasurer.

The Committee voted to accept the resignations of the following members:

FLOYD ANDRE	F. C. FLETCHER	J. A. G. REHN
BERNARD BENESH	F. W. FLETCHER	C. A. THOMAS
G. M. BOUSK	J. G. FRANCLEMONT	P. C. TING
H. W. CAPPS	J. L. PELTON	K. V. KROMBEIN
W. B. CARTWRIGHT		

The Committee appointed the following to serve as members of the Editorial Board of the *Annals* in the class of 1955: D. J. BORROR, RAY F. SMITH and PAUL WOKE.

The Committee appointed the following to serve as members of the Thomas Say Foundation in the class of 1954: R. L. USINGER and W. J. BROWN.

It was resolved that since DR. GURNEY was not able to present the report of the General Welfare Committee in person that his report be forwarded to the Interim Governing Board with the suggestion that it be given early consideration.

The committee appointed the officers of the Sections of Taxonomy and Physiology.

Taxonomy: Chairman—H. E. EVANS
Vice-chairman—E. S. ROSS
Secretary—MELVILLE HATCH

Physiology: Chairman—S. D. BECK
Vice-Chairman—R. L. METCALF
Secretary—MORRIS ROCKSTEIN

The executive committee elected the following as Fellows:

F. H. BABERS	R. W. FAY	L. M. ROTH
R. E. BUGBEE	GOTTFRIED FRAENKEL	H. F. SCHOOF
L. E. CHADWICK	P. A. GLICK	KATHRYN SOMMERMAN
J. T. CREIGHTON	E. S. HATHAWAY	H. T. SPIETH
C. K. DORSEY	CLAY LYLE	G. J. SPENCER
K. C. EMERSON	H. H. NESBITT	P. A. WOKE

The applications for membership of J. S. KARAM and RICHARD H. ROBERTS were approved. (A total of 26 new members for 1952.)

The committee voted to continue the joint committee on Entomological Nomenclature by moving all classes along one year. It was decided to fill one vacancy with the appointment of J. L. LAFFOON.

On motion these portions of the Secretary's report were approved as read.

Separate action was taken on the following item: Resolved, that the Society contribute $100.00 to the Zoological Society of London in support of the Zoological Record. A motion to approve this action was made and carried.

Respectfully submitted,

A. C. HODSON, *Secretary.*

REPORT OF THE TREASURER

CURRENT FUND

Balance on hand December 24, 1950	$3,534.09
Receipts from dues	3,313.17
Transferred from Managing Editor	1,800.00
Total	$8,647.26

EXPENDITURES

Annals (4 numbers)	$6,850.15	
Reprints and mailing back numbers	94.24	
Expenses former Secretary-Treasurer	179.15	
Expenses Secretary's Office	216.10	
Travel, Secretary's Office	260.01	
Expenses of Treasurer's Office	51.91	
Contribution to Zoological Society, London	101.00	
Transfer to Savings Account	1.44	
Total	$7,754.00	
Balance in bank December 2, 1952	893.26	
Total	$8,647.26	

PERMANENT FUND

Balance on hand December 24, 1951	$4,659.85
Interest and coupons	24.94
Balance on hand December 2, 1952	$4,684.79
Liberty Bond	50.00
Total	$4,734.79

TOTAL RESOURCES OF THE SOCIETY

Balance in Current Fund	$ 893.26
Balance in Permanent Fund	4,734.79
Total	$5,628.05

Respectfully submitted,

S. W. FROST, *Treasurer.*

REPORT OF THE TREASURER OF THE THOMAS SAY FOUNDATION

PERMANENT FUND

Balance on hand January 13, 1952	$5,599.74
Book sales 1952	168.63
Interest on savings account	21.99
Deposited to account by error	1.44
Total	$5,791.80

CURRENT ACCOUNT

From book sales for current expenses		$ 6.50
Postage	$3.25	
Refund	.65	
Transfer to Entomological Society of America	1.44	
Total	$5.34	
Balance on hand December 2, 1952		$ 1.16

Respectfully submitted,

S. W. FROST, *Treasurer.*

REPORT OF THE MANAGING EDITOR

Volume 45 of the ANNALS will contain approximately the same number of pages as Volume 44, that is, about 650. Of these, costs of publication have been paid for five articles aggregating 77 pages. This compares favorably with the two preceding volumes, which aggregated 51 and 91 pages of paid articles respectively. Acceptable manuscripts have been received at approximately the same rate as in the past few years, so the backlog remains approximately the same.

An advertising policy has been formulated, thanks to the efforts of Drs. C. E. Palm, W. E. Dove, and R. L. Metcalf. A schedule of costs has been adopted on the following basis: Full page, $35.00 per issue, $100 per year; half page, $20.00 per issue, $50.00 per year. Our advertising in Volume 45 will aggregate less than five pages, but the results of solicitation are encouraging. Now that the policy is formulated, revenue from advertising sources should enable us materially to increase our issue.

The physiological papers have been handled much more effectively and satisfactorily now that we have an editor in charge of that area. Dr. Richards has done an excellent job during his first year's service in that capacity, and papers in that field have been thoroughly, carefully, and promptly edited.

My secretarial work has been done this year by my wife, Mrs. Helen James. The time that she has willingly and uncomplainingly spent has been well in excess of that justified by the remuneration of $25 a month which she has received for that purpose.

The following is a financial statement for the year 1952.

FINANCIAL STATEMENT

NOVEMBER 2, 1951, TO NOVEMBER 6, 1952

Bank balance, First National Bank of Pullman, November 2, 1951		$1,090.48
RECEIPTS		
For cuts and postage		$ 714.95
From institutions for publication costs		856.33
Received from Columbus Office		2,237.33
Total Receipts		$4,899.20
DISBURSEMENTS		
Salaries		$ 648.00
Postage and telegraph		126.00
Travel expenses		219.55
Office expenses		21.01
Refunds on subscriptions		27.00
Engraving		1,021.12
To Spahr and Glenn Company for reprints		34.30
Transferred to S. W. Frost, Treasurer		1,800.00
Total		$3,896.98
Bank balance, First National Bank of Pullman, November 6, 1952		1,002.22
Total		$4,899.20

Respectfully submitted,

MAURICE T. JAMES, *Managing Editor.*

REPORT OF THE AUDITING COMMITTEE

I have examined the books of the Treasurer for the period January 13, 1952, to December 2, 1952, and find them to be correct.

S. E. FLANDERS, *Chairman.*

A motion was made and carried to accept these financial reports as read.

REPORT ON THE THOMAS SAY FOUNDATION

Volume V, "Aphids of the Rocky Mountain Region," by MIRIAM A. PALMER, will be available very soon. Very generous contributions to the Foundation have been received during the year. Effort is being directed toward getting an opinion from the Department of Internal Revenue on the question of tax exemption on donations made to the Thomas Say Foundation.

Respectfully submitted,

J. J. DAVIS.

REPORTS OF STANDING COMMITTEES

AMERICAN COMMITTEE ON ENTOMOLOGICAL NOMENCLATURE

The Committee has discussed at length, by correspondence, certain problems concerning entomological nomenclature and has prepared reports on (1) ordinal names, (2) family names, (3) neotypes, and (4) emendations which were forwarded in August to the Secretary of the International Commission on Zoological Nomenclature.

C. D. MICHENER, *Secretary.*

REPORT OF REPRESENTATIVE TO DIVISION OF BIOLOGY AND AGRICULTURE, NATIONAL RESEARCH COUNCIL

The Division of Biology and Agriculture, National Research Council, held its annual meeting at the National Academy of Sciences-National Research Council Building in Washington, on Friday, May 2, 1952, with DR. PAUL WEISS, Chairman, presiding. Minutes of the preceding annual meeting were distributed and a roll call of the representatives of the member societies was taken. Chairman Weiss spoke briefly of the history of the National Academy of Sciences and the National Research Council, emphasizing the importance of the biological societies to the Council. He stated that the Division must function in the preservation of unity, perspective and balance in the field of biology as a whole. It was announced that there had been created or there were plans for creating within the Division the following new committees or boards:

(1) An *Agricultural Research Institute* the membership of which is made up of industries, trade organizations and non-profit institutions concerned with the development and utilization of agricultural products. The function of the Institute is to help underwrite activities of the Agricultural Board and to insure close relations between scientific developments and practical applications.

(2) A *Committee on Plant and Crop Ecology* to be concerned with problems and needs in the area of plant growth as related to factors influencing yield. One of the six subcommittees will deal with plant diseases and pests.

(3) A *Committee Council* within the Division of Biology and Agriculture to consist of six advisory committees representing the whole field of Biology and concerned with making recommendations for its development. Committee membership would be non-inclusive of Society representatives.

(4) A *Committee on Animal Procurement* has been established to help with problems relating to the increasing demands for animals for biological and agricultural research and tests.

The program for the day was largely concerned with presentation of committee reports. Dr. John Field of the Division of Biology, National Science Foundation, was present and outlined some aspects of the Foundation's program.

The Committee on the Naples Zoological Station reported that the American Table at the Station had been re-established. The subcommittee on Pesticides of the Food Protection Committee, Food and Nutrition Board, is evaluating basic requirements for determining the certification of new pesticides. The American Institute of Biological Sciences is now composed of 18 member Societies and 6 affiliate Societies with a membership of around 14,000. Reported activities of the Pacific Science Board include development of studies on the Insects of

Micronesia. The Society of Systematic Zoology was approved for membership in the Division.

Respectfully submitted,

H. M. HARRIS.

REPORT OF REPRESENTATIVE TO THE COUNCIL OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Dr. JOHN J. PRATT presented an oral report of the Council activities for the year.

REPORTS OF SPECIAL COMMITTEES

ADVERTISING

In the absence of the committee chairman, DR. MAURICE JAMES commented on attempts that have been made to obtain advertising copy for the *Annals*. He reported that some advertising will be included in future issues.

JOINT COMMITTEE ON THE DEVELOPMENT OF INSECT TAXONOMY

DR. MILLS reported on efforts that are being made to determine where future support for work in Taxonomy may be available. He outlined the essential features of a questionnaire that will be circularized. Considerable interest was raised by his oral report as evidenced by the number of questions asked and suggestions offered.

RESOLUTIONS COMMITTEE

WHEREAS, the officers of the Entomological Society of America have promoted the interests of the Society in a most efficient manner during the past year,

Therefore, be it Resolved, that the Society express its sincere thanks to DR. E. GORTON LINSLEY, DR. A. C. HODSON, DR. MAURICE T. JAMES and the other officers and members of the executive committee, for their diligent work on behalf of the Society.

WHEREAS, the Annual Public Address of the Entomological Society of America is one of its major traditions, and

WHEREAS, DR. A. GLENN RICHARDS gave a most scholarly and instructive address,

Therefore, be it Resolved, that the Society express its sincere appreciation to DR. RICHARDS.

WHEREAS, the arrangements for the Philadelphia meetings were most capably handled by the local arrangements committee, and a most interesting program was arranged by the program committee,

Therefore, be it Resolved, that the Society express its sincere appreciation to the members of both committees for their efforts.

WHEREAS, the Society regrets the loss by death of several members during the past year,

Therefore, be it Resolved, that the secretary of the Society be instructed to write a letter of sympathy to each of the families of the deceased members.

A. EARL PRITCHARD,
A. B. GURNEY,
CLARENCE E. MICKEL, *Chairman*.

A motion to accept this report was made and carried.

The following resolution was prepared and presented by CURTIS W. SABROSKY.

Resolved, that the Entomological Society of America, at this its final meeting before amalgamation with the American Association of Economic Entomologists, express its deep regret at the loss of those members who have resigned, or may resign because of amalgamation; that the Society express the hope that those members may in the future find it possible to join the new Entomological Society of America, and that the secretary be instructed to send a copy of this resolution to those members.

A motion to accept this resolution was carried.

DR. E. GORTON LINSLEY turned over the gavel to the newly-elected President of the Society, DR. H. H. ROSS. There being no new business the meeting was adjourned.

Respectfully submitted,

A. C. HODSON, *Secretary*.

OBITUARIES

JAMES AUGUSTUS HYSLOP
1884–1953

Few men have entered the field of entomology with such enthusiasm for insects as James Hyslop. Not only was he known for his outstanding taxonomic studies of the Elateridae, his pioneer work in the establishment of modern insect surveys, but also for his broad knowledge of entomology. He studied weather in relation to insects and was the first to compile a comprehensive article on insect losses.

In America, for a quarter of a century, interest in wireworms was centered on control. Then in 1917 Mr. Hyslop published the results of a study of the larval characters for the identification of the major subdivisions of the Elateridae and their phylogenetic relationship. This paper, "The Phylogeny of the Elateridae Based on Larval Characters," appeared in the Annals of the Entomological Society of America 10: 241–263. Concerning the work, Dr. Robert Glen, of Canada, says: "Supporting his conclusions by both adult and larval studies, Hyslop improved upon the pioneer work of Schiodte and Henriksen and established a reliable basis for progress in this field of research." "Larva of *Tetrigus fleutiauxi* Van Zwaluwenburg," by Hyslop and Adam Böving is also considered by Dr. Glen as "an excellent contribution to the morphological literature" and "a useful model for future investigators to follow." An important contribution to the biology and ecology of wireworms of the tribe Lepturoidini was made by Mr. Hyslop in his paper, "Wireworms Attacking Cereal and Forage Crops." In 1921 his "Genotypes of the Elaterid Beetles of the World" was published.

Although his interest in classification and ecology of wireworms continued, another field of entomology beckoned him on. During World War I his work in the present Bureau of Entomology and Plant Quarantine brought him in contact with entomologists in extension work. He quickly saw the need of collecting data on economic insects and publishing it to inform these workers of insect conditions. Former insect surveys usually consisted of geographical records only but Mr. Hyslop foresaw the need also for data on biology, ecology, and hosts to be kept on permanent record. From a study of this information, insect abundance could be predicted. He pursued this plan with such vigor that the Insect Pest Survey of the Bureau was finally created in March 1921 and its first Bulletin appeared the following May.

Mr. Hyslop was in charge of the Survey since its inception and the Division of Insect Pest Survey and Information since its creation in 1934. He so vividly saw the value of the modern survey that he persuaded many entomologists to create a state survey of their own patterned on the Federal one.

Despite the period of intense work of organizing and expanding the survey he did not forget wireworms. He snatched time to do some preliminary (though never published) work on the classification of the larvae of the whole family of Elateridae with Dr. Böving, and for a few years to teach a course in advanced insect taxonomy at night at the University of Maryland.

James Hyslop undertook the third major job of his life about 35 years ago when he began his "Encyclopedia of Economic Insects of North America (North of Mexico)" with the object of putting into the hands of entomologists a ready and comprehensive reference to insects of economic importance. He knew the difficulties that workers in entomology and related fields encountered when they were forced to hunt through literally hundreds of publications to find the life history as well as other important data about insects. Although he died (January 16, 1953, at his home) before the book was completed, he had the foresight to interest a younger entomologist in it and chose the writer as a collaborator to complete and publish the encyclopedia.

Life for Mr. Hyslop began on July 7, 1884, in Chicago, Illinois. He received his B.S. degree from the present University of Massachusetts at Amherst in 1908. Forty years later he was presented by the Dean with an academic medal (an award not instituted until recent years) for his extra-curricular activities among which were his fine sketches made in the 1908 university yearbook. In 1911 he obtained his M.S. degree from the State College of Washington and was employed by the Bureau from 1907 until 1944, when he retired. Mr. Hyslop was a member of the following societies: Entomological Society of America (fellow, 1935; first vice-

president, 1936), American Association of Economic Entomologists, Entomological Society of Washington (president, 1927), Washington Academy of Sciences, and American Association for the Advancement of Science (fellow). He was also a member of Pi Gamma Mu and the Cosmos Club.

His hospitality drew entomologists and friends from all parts of the world to his home, "Cameronia," Silver Spring, Maryland. Here his interesting family (his wife, Grace; his children, Charles, James, Ryntha, and Wynnifred; and his sister, Catherine), all of whom survive him, became known to many.

The friends of Mr. Hyslop consider it a privilege to have met a man with such a vibrant personality and keen mind. Whether we knew him as an entomologist, writer, artist, gardener, or friend, we never failed to capture from him a spark of his great zest for life.

HELEN SOLLERS.

HENRY TORSEY FERNALD

Henry Torsey Fernald, a charter member of the Entomological Society of America, a fellow since 1914, and an honorary fellow since 1937, was born April 17, 1866, in Litchfield, Maine, the son of Charles Henry and Maria Elizabeth (Smith) Fernald, both of whom were recognized internationally for their work in entomology. Henry T. Fernald received his early school and college education at Orono, Maine, where the family lived from 1871 to 1886. His degree of B.S. was obtained there in 1885 and the M.S. in 1888, also at the University of Maine. The degree of Ph.D. was received in 1890 from Johns Hopkins University in Baltimore, where he was married to Minna R. Simon on June 9th of the same year. Dr. and Mrs. Fernald had three children, Helen Elizabeth, Charles Henry and Ruth Louise (Mrs. Carl B. Stone).

From 1890 to 1899, Dr. Fernald was Professor of Zoology at Pennsylvania State College, also holding the position of State Zoologist during his last year there. In 1899 began a long and distinguished service at the Massachusetts Agricultural College in Amherst, Massachusetts, where the father, Professor Charles H. Fernald, had gone as Professor of Zoology in 1886. Dr. Fernald began his work as Professor of Entomology there in September 1899, one of his immediate tasks being the organization of graduate courses in entomology. Added to his duties were such positions as those of State Nursery Inspector (1902 to 1908), Acting Director of the Graduate School (upon the retirement of his father from this position until 1913), Chairman of the Division of Science (1913 to 1927), and Director of the Graduate School (1927 to 1930). Suffering severely from bronchitis and asthma, Dr. Fernald from 1927 spent the winter term (January through March) in Orlando, Florida. He retired as emeritus professor of entomology June 30, 1930 and moved permanently to Florida. Here he established his home finally in Winter Park, close to the campus of Rollins College. Here he spent over twenty years, passing away on July 15, 1952, at the age of 86. He is survived by Mrs. Fernald and his two daughters.

Dr. Fernald was a member of many scientific societies, including the American Association of Economic Entomologists of which he was President in 1914 and later elected honorary member. His work and writings embraced many fields, particularly economic entomology and the taxonomy of sphecid wasps. His earliest writings in entomology appear to have been published in 1890—"Studies on *Thysanuran* Anatomy,–" (*in* Johns Hopkins Univ. Circ. no. 80: 62–63, with a summary in J. Roy. Microscop. Soc., 1890, 452), and "Rectal Glands in Coleoptera" (*in* Am. Naturalist 24: 100–101, 2 pls.). He had a great interest in type nomenclature, and in the problems associated with the teaching of entomology. In the earlier years of his retirement he collected insects extensively in Florida, and wrote many short articles recording his interesting observations. Mrs. Fernald accompanied him on his expeditions and painted the wild flowers of the State, a considerable collection of her paintings, it is understood, now being exhibited in Gainesville, Florida.

Dr. Fernald is widely known also for his textbook on "Applied Entomology", first published in 1921, revised by him in 1926 and again in 1935, and with some assistance from this writer revised still again in 1942. His long years of experience in teaching entomology were exceedingly valuable to him here. The book has

been used as the basis for beginning courses in entomology in many schools and colleges in this country and abroad. Dr. Fernald stated at one time that it had never occurred to him that there would be a continuing demand for his book and that he would be called upon by his publishers for successive revisions.

Dr. Henry T. Fernald was a distinguished teacher and administrator in entomology. Busy as he was, he always had time for the problems of his students and associates. All who knew him, but especially these, will hold him in kind memory for his assistance always freely given (not alone in entomology) and for his patience and good nature with them at all times.

HAROLD H. SHEPARD.

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PALMER'S "APHIDS"

"Aphids of the Rocky Mountain Region" by Miriam A. Palmer has just been published by the Thomas Say Foundation. It consists of 452 pages, 8 colored plates, and 455 figures of line drawings providing additional accuracy in identification. Keys are provided for the subfamilies, tribes, genera and species.

Although the title indicates a restricted area, as a matter of fact, the volume includes practically all of the species in North America, north of Mexico.

The volume is priced at $10.25 postpaid in the United States, and for other countries $10.50 postpaid. It can be obtained from

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Checks should be made payable to the Thomas Say Foundation.

BOOK NOTICES

THE GRASSHOPPERS AND LOCUSTS (ACRIDOIDEA) OF AUSTRALIA, VOL. I, TETRIGIDAE AND EUMASTACIDAE, by JAMES A. G. REHN. Pp. 328, 21 plates. Commonwealth Scientific and Industrial Research Organization, Melbourne. 1952. Price, £2.0.0.

AUSTRALIAN TERMITES, THEIR BIOLOGY, RECOGNITION, AND ECONOMIC IMPORTANCE OF THE COMMON SPECIES, by F. N. RATCLIFFE, F. J. GAY, and T. GREAVES. Pp. 124, 20 figs. Commonwealth Scientific and Industrial Research Organization, Melbourne. 1952. Price 15/-.

The first of these two contributions to our knowledge of the Australian insect fauna is essentially taxonomic in nature. It is a comprehensive monograph of the families Tetrigidae and Eumastacidae, with keys, synonymy, distributional information, extended descriptions, and a wealth of illustration. The 287 figures, arranged in 21 plates, include both photographs and line drawings. The large number of new species and genera is surprising, especially in view of the recent monographs of the Australian Acridoidea (1921, 1935) by Sjöstedt. A good grade of glossy (but not too shining) paper is used, and the monograph presents a very good appearance.

The volume on termites is written more from the biological standpoint. Its taxonomic aspects are confined to the presentation of a generic key to soldiers, some notes on taxonomy, and the distinction of the more important species by means of diagnoses and comparisions, rather than by keys and extensive descriptions. The authors are much more interested in presenting an account of termite habits, colony foundation and mound building, general biology, economic aspects, and control. Their book is designed as a handbook for the non-specialist, thus filling a need not served by Hill's (1942) monograph of the Australian termites.

M. T. J.

SYSTEMATIC STUDIES IN PLECOPTERA, by WILLIAM E. RICKER. Pp. 200, 154 figs. Indiana University Publications, Science Series No.18. 1952.

This carefully prepared treatment of certain groups of stoneflies is Dr. Ricker's latest contribution to our knowledge of the Plecoptera. The main body of the paper consists of an introduction and three sections: a monograph of the genus *Nemoura* in North America, a treatment of the family Perlodidae from a world-wide standpoint, and a section devoted to miscellaneous descriptions and revisions. A bibliography of major cited works and an index of scientific names follow the systematic sections.

The introduction outlines the principal history of stonefly classification in North America, acknowledges material sent for identification, describes in general terms the contents of the three systematic sections, and presents a phylogenetic tree for the Plecoptera. Concerning the phylogeny of the order, recent study of *Peltoperla zipha* Frison allies the family Peltoperlidae more closely with the main stem of stonefly evolution and less closely to the family Nemouridae, and discovery of the new genus *Utaperla* more closely links the Isogeninae and Chloroperlinae than did the two previously known genera in the subfamily Paraperlinae.

Part I, treating the North American species of the genus *Nemoura*, is the first serious attempt to show the relationships that exist among them, and for the first time a key to the females is presented. Ricker places the 47 known North American species in 12 subgenera, 9 of which are described as new, 3 of which are monotypic.

Part II, a systematic treatment of the family Perlodidae, presents an exhaustive study of the species in North America and also lists the exotic species according to current assigned genera and subgenera. The classification proposed depends

largely on the morphology of the male genitalia; it is not possible to place all nymphs and all females to their proper genera, though the thoracic sternal pattern and the arrangement of external gills, for those species possessing them, enable the correct placements of many forms. The family is divided by Ricker into three subfamiles, Isogeninae, Perlodinae, and Isoperlinae. The author places 39 North American species of Isogeninae in 2 genera comprising 19 subgenera, 9 of which are described as new; five specific names are not assigned to subgenera. Ricker's conception of the Perlodinae includes four genera, three of which are confined to the palearctic and the fourth also represented in North America by two subgenera representing three species. Only two genera are placed by the author in the subfamily Isoperlinae, *Isoperla* and the monotypic *Calliperla*. *Isoperla* is not treated exhaustively; a monograph of this difficult genus awaits another worker.

Part III contains miscellaneous revisions and descriptions of North American species. Species treated include members of the following genera: *Pteronarcys*, *Peltoperla*, *Brachyptera*, *Allocapnia*, *Leuctra*, *Utaperla* (*new*), *Alloperla*, *Chloroperla*, *Hastaperla*, *Claassenia*, and *Neoperla*.

The only significant criticism which might be directed towards this monograph is the splitting of genera into so many subgenera, but by so doing much is gained toward understanding the relationships between species.

This major contribution to Plecopterology is well-written, the illustrations for the most part are quite satisfactory, the keys are remarkably free from error, and the distributional notes for each treated species are of much value. The style of presenting characteristics of the numerous subgenera in tabular form facilitates an understanding of Ricker's classification concepts and aids greatly in identification.

STANLEY G. JEWETT, JR.

THE ENTOMOLOGICAL REVIEW OF JAPAN. This relatively new journal is devoted to the Coleoptera. Most of the articles are taxonomic, but some deal with biology, ecology, immature stages or history. Most of the taxonomic papers are in English and the notes and biological papers in Japanese. A few are in German. The journal is published by the Kinki Colepterological Society, Osaka, Japan. Two numbers are issued per year. Volume 1, number 1 was published in April 1948 and after the first volume the Review merged with Transactions of the Kinki Colepterological Society following volume 4, no. 2 of the latter, as volume 5, no. 1 of the Review (1950). Thus there are no volumes 2 to 4 of the Review. Volume 6, no. 2 of the Entomological Review of Japan was published in September, 1952. The managing editor is Masao Hayashi, at 27, 5-chome, Hiranomachi, Higashi-ku, Osaka, Japan.

J. L. GRESSITT.

BRITISH PYRALID AND PLUME MOTHS, by BRYAN P. BEIRNE. Pp. 208, 405 figs., 216 in color. Frederick Warne & Co., Ltd., London & New York. Price, $5.00.

At first glance a modest work, this is actually an extremely thorough and authoritative book on the British moths of the three families Pyralidae (*sic*), Orneodidae and Pterophoridae. Although published as one of a series of books on British natural history it is scientifically worthwhile in every way, a fact that unhappily needs be called to the attention of many Americans whose ideas of natural history books are based on the superficial hack work often published in this country. A total of 210 species are treated, all that have been recorded from the area. Terse dichotomous keys are given for the familes, subfamilies and genera, and for the species of all polytypic genera. All but a few very rare species are figured in color. The black-and-white illustrations show representative structural details of importance in taxonomy such as heads, legs, venations,

genitalia and details of larval structures. Quite a few distribution maps are included. Many species are also figured in black-and-white. An excellent series of landscape cross-sections show the relative habitats of many species in a number of different environments. In the text are given very full accounts of the known details of the habitats, life histories and phenology of each species, and many details of great value to the collector about the haunts and habits of the adults. Many of these notes are of great interest to the ecologist of any continent. A selected bibliography and a very useful glossary complete the work. The only major omission is that of the genitalia, which are not figured or used in the keys. However, as the author points out, these have been thoroughly discussed and figured in the recent "The Genitalia of the British Pyrales . . ." by Pierce and Metcalf (1938), so that their inclusion here would be largely superfluous. It is a great pity that such a fine and scholarly book should be marred by the extremely poor quality of the colored illustrations (at least in the review copy which I received) a majority of which are so badly off-register as to be nearly useless. This is, of course, the responsibility of the publisher. The book should, however, be very useful to many students and workers in this country, where many of the species and a large number of the genera also occur. It may also serve as an excellent model for similar works on our own biota.

ALEXANDER B. KLOTS.

I have been informed by the author, however, that a new edition of this book is being prepared. In addition to containing new textual material, this will have a set of new color illustrations prepared by S. N. A. Jacobs, who is himself a well known student of the Pyralididae.

A. B. K.

A TEXTBOOK OF ARTHROPOD ANATOMY, by R. E. SNODGRASS. Pp. viii + 363, 88 figs. Comstock Publishing Associates, Ithaca, New York. 1952. Price, $6.00.

The work of Mr. Snodgrass is so well known that a new book by him does not require critical analysis; it is sufficient to say that it was done with his usual thoroughness and carefulness. His *Textbook of Arthropod Anatomy* is a welcome addition to entomological literature. It is not easy reading; it is meaty and for its digestion requires thorough study, with constant reference to the illustrations. It treats the arthropods by types rather than by systems, and its methods are those of descriptive anatomy, rather than the more philosophical methods of morphology. Consequently, it by no means duplicates the *Principles of Insect Morphology;* the two make companion volumes.

All major groups of arthropods extant and extinct, are discussed. The Trilobita, Eurypterida, Pycnogonida, Diplopoda, Pauropoda, and Symphyla are considered as groups, the discussion being based either on a hypothetically typical form or upon variations around a typical structural pattern. In the discussion of the other groups, the Xiphosurida are represented by *Limulus;* the Arachnida, by a scorpion, spiders and the tick *Dermacenter:* the Crustacea, by the primitive shrimplike *Anaspides*, the crayfish *Cambarus*, and the isopod *Ligyda;* the Chilopoda, by *Scutigera*, *Lithobius*, *Otocryptops*, and a geophilid; and the Hexapoda by the dipluron *Heterojapyx*, the Thysanura, and the cockroach *Periplaneta*.

M. T. J.

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Papers should ordinarily be submitted directly to the Editor. However, they may be submitted to any member of the Editorial Board, especially where such member is particularly qualified in the subject matter of the paper.

Any illustrated manuscripts submitted must be accompanied by finished illustrations which are ready for reproduction (or by engravings plus proof if the author prefers to have his own made). The price of zinc cuts or half-tone engravings in excess of one page of cuts for each twelve pages of printed matter will be charged to the author at cost. It is to be noted that text, tables, zinc cuts and half-tone engravings are all printed alike on one quality of paper at the standard 4¼ x 6¾ inch size. If an author has tabular material or illustrations that require another size or a special paper, such is obtainable only by special arrangement with the editor and at the expense of the author.

Acceptable style and format depends to some extent on the subject matter to be treated. Authors are referred to recent issues of the journal for the usual styles.

Since the Annals is not a copyrighted journal, permission to quote or to use illustrations is within the province of the author or authors.

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Requests for membership and annual dues to members should be sent to Dr. Ernest N. Cory, Secretary-Treasurer (Acting), College Park, Maryland.

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The stock of back numbers of the ANNALS is now in charge of The Spahr and Glenn Company, 50 East Broad Street, Columbus 15, Ohio, by whom all shipments will be made, but orders should be addressed to Mrs. Helen S. Lanman as above.

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